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A SOLUTION TO THE PROBLEM OF ADJUSTING THE COUNTERBALANCE OF A SHIPBOARD THEODOLITE

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The usual shipboard theodolite is essentially a sextant mounted on gimbals and equipped with a horizontal circle. In order to keep the sextant upright in the gimbal mounting, a shaft with a heavy weight or counterbalance on it is rigidly attached to the outer spindle of the horizontal circle assembly. On some types of instruments, such as that shown in figure 1, this weight or counterbalance may be adjusted vertically. In the use of such an instrument, then, the problem naturally arises as to what is the optimum counterbalance adjustment for a given set of conditions aboard ship.

As far as can be learned, the only reference to any attempt to solve this problem is that contained in an article written by F. Eredia on the "Exploration of the Atmosphere by Means of Pilot Balloons on Board Merchant Vessels" which was published in volume IV the "Annali dell'Ufficio Presagi" appearing in 1932. A translation[1] of his remarks regarding the problem of offsetting the effects of the motion of the ship is as follows:

> This problem has been solved by supplying a Cardan suspension (gimbal mounting) with a pendulum rigidly attached to it (the theodolite)—giving the pendulum sufficient mass since the center of gravity should be rather low. The length of the pendulum may be varied continuously in such a manner as to modify the period of oscillation so that it avoids resonance with the period of oscillation of the ship. Moreover, three springs notably reduce the oscillation of the pendulum itself.
>
> Experience has shown that, having once regulated the period of the pendulum by means of trial in the best possible manner, pilot balloon soundings can be taken with the same ease as on land.

Since conditions, as far as the motion of a given ship is concerned, vary greatly from time to time—depending upon the type of sea encountered and the ship's heading into it among other things—it is believed that it will be of considerable advantage to be able to compute the optimum position of the counterbalance for a given set of conditions aboard ship. To this end, the following investigations have been pursued:

To begin with, the problem as to the proper counterbalance adjustment for a free suspension (i. e., without springs) of the theodolite was considered and an attempt was made to apply the classical equation for forced vibrations with viscous damping to it. To do this the following assumptions and limitations were imposed initially:

1. The motion of the theodolite was considered to be confined to a single plane—this plane being that perpendicular to the axis of the most pronounced angular motion of the ship—its roll.
2. It was assumed that the theodolite had been so oriented that the axis about which the instrument oscillates within the gimbal ring was parallel to the ship's axis of roll.
3. It was assumed that it would be possible, finally, to so adjust the counterbalance that its amplitude of oscillation with respect to the vertical would be less than 3°.
4. Damping proportional to the first power of the angular speed with respect to the vertical (viscous damping) was assumed. The torques due to other types of damping were assumed to be negligible.
5. In accordance with the theory of the seismograph, the inertia effect on the part of the instrument on gimbals was assumed to be concentrated at its center of gravity.
6. The error introduced by considering the direction of the acceleration of the point of suspension due to the roll of the ship to be at all times normal to the counterbalance shaft was assumed to be negligible.
7. The effect of any torques which might arise when the theodolite moves through the air with the rolling of the ship or which might arise due to the blowing of the wind is assumed to be negligible.

Under these assumptions, then, the equation of motion is:

$$\frac{d^2\theta}{dt^2}+\frac{\kappa d\theta}{dt}+\frac{g\theta}{\lambda}=\frac{-Mh}{K}\frac{d^2y}{dt^2} \tag{1}$$

where

θ is the angle which the theodolite makes with the vertical,

κ is the factor by which the angular speed must be multiplied in order to obtain the angular acceleration due to damping,

t is the time,

g is the acceleration of gravity,

M is the mass of the part of the instrument on gimbals,

h is the distance of the point of support from the center of gravity of the part of the instrument on gimbals,

K is the moment of inertia of the part of the theodolite on gimbals,

$\lambda=\frac{K}{Mh}$ is the length of the equivalent simple pendulum,

and

y is the displacement (along the arc) of the point of support from its equilibrium position.

If, now, Y being the maximum displacement along the arc of the point of support from its equilibrium position and p being 2π divided by the period of roll of the ship, the equation

$$y=Y\cos pt \tag{2}$$

is assumed to hold, then

$$\frac{d^2y}{dt^2}=-Yp^2\cos pt \tag{3}$$

Letting Φ_0 represent the amplitude of roll of the ship and H the distance of the point of support of the instru-

[1] Furnished by Carl Russo of the Aerological Division.

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ment from the axis of roll of the ship, equation (3) becomes

$$\frac{d^2y}{dt^2}=-\Phi_0 Hp^2 \cos pt \tag{3a}$$

Substituting in equation (1), the required differentia equation becomes

$$\frac{d^2\theta}{dt^2}+\kappa\frac{d\theta}{dt}+\frac{g}{\lambda}\theta=\frac{\Phi_0 Hp^2 \cos pt}{\lambda} \tag{4}$$

The expression for the amplitude of vibration obtained from this equation is found to contain, among others, the constant κ. In order to evaluate this constant, the logarithmic decrement of the theodolite was measured. It was found, however, that instead of having a constant logarithmic decrement, as is demanded by the assumption of viscous damping, the decrements in the amplitudes of free swing were approximately constant. This means that instead of the angular acceleration due to friction being represented by the expression $\kappa\frac{d\theta}{dt}$ it must be represented by a constant. This is evident from the following considerations:

If θ_1 represents the amplitude of any swing of the instrument other than any one of the final three swings before the instrument comes to rest, and θ_2 and θ_3 be the succeeding amplitudes of swing, the angular acceleration is:

$$\frac{\frac{4}{T}\left(\theta_1-\frac{\theta_1-\theta_2}{4}\right)-\frac{4}{T}\left(\theta_2-\frac{\theta_2-\theta_3}{4}\right)}{T}$$

where T represents the natural period of swing of the instrument. Letting $\Delta\theta$ represent the constant decrement of the amplitude of swing, the expression $\frac{4\Delta\theta}{T^2}$ is finally obtained for the frictional angular acceleration. Since T may, for the purposes of this investigation, be regarded as a constant, it follows then that the resulting angular acceleration is constant.

Letting F represent the value of this constant, then, the equation of motion of the theodolite assumes the form:

$$\frac{d^2\theta}{dt^2}+\frac{g}{\lambda}\theta\pm F=\frac{\Phi_0 Hp^2}{\lambda}\cos pt, \tag{5}$$

the plus sign before F being used for one direction of swing and the minus sign being used for a swing in the opposite direction. A solution of this equation has been published by Den Hartog in Vol. 53 of the *Transactions of the American Society of Mechanical Engineers* (Section APM, page 107). Den Hartog, however, substitutes the expression $\cos(pt+\phi)$ for $\cos pt$ so that the equation to be solved finally becomes

$$\frac{d^2\theta}{dt^2}+\frac{g}{\lambda}\theta\pm F=\frac{\Phi_0 Hp^2}{\lambda}\cos(pt+\phi). \tag{5a}$$

This change was made "for the purpose of subsequently writing the boundary conditions in a simple form." Selecting the negative sign before F the solution of this equation, which corresponds to Den Hartog's (6), is

$$\theta=\theta_0\cos p_nt+\frac{F}{p_n^2}(1-\cos p_nt)+\frac{\Phi_0 Hp^2}{\lambda(p_n^2-p^2)}\left[\cos\phi(\cos pt-\cos p_nt)+\sin\phi\left(\frac{p}{p_n}\sin p_nt-\sin pt\right)\right] \tag{6}$$

where $p_n=\sqrt{\frac{g}{\lambda}}$. The values of $\cos\phi$ and $\sin\phi$ may be obtained as is shown by Den Hartog (with the exception that a positive instead of a negative sign should be used for the given values of $\sin\phi$) and there results, then, as the equation corresponding to Den Hartog's equation (9)

$$\theta_0^2=\frac{\Phi_0^2H^2p^4}{(g-\lambda p^2)^2}-\frac{L^2}{MhKgp^2}\frac{\sin^2\frac{p_n}{p}\pi}{\left(1+\cos\frac{p_n}{p}\pi\right)^2} \tag{7}$$

where $L=K\times F=$the torque due to friction.

When the function of the form $\frac{\sin u}{1+\cos u}$ contained in the last term on the right-hand side of this equation is examined, it is found to become indeterminate whenever u assumes any of the odd integral multiples of π as a value. An application of L'Hospital's rule for evaluating indeterminate forms to this function shows that it becomes infinite at these points. Since the coefficient of the square of this function does not vanish for finite distances of the counterbalance from the point of suspension and the first term on the right-hand side becomes infinite only when λp^2 approaches g as a limit (which, assuming that the period of roll varies between 6 sec. and 20 sec., can happen only if λ takes on a value lying between 10 and 10,000 meters), it might appear that this equation would give negative values of θ_0^2 at the points in question. As Den Hartog has pointed out, however, a limiting condition as to the application of (7) is furnished when it is considered that the negative sign before F was chosen in obtaining the desired solution. This, of course, means that $\frac{d\theta}{dt}$ must be considered negative for the interval for which (7) applies. When equation (6) is differentiated with respect to the time and this fact is utilized, it is found that the relation

$$\theta_0>\frac{F}{pp_n}\,\frac{\sin p_nt+\dfrac{\sin\frac{p_n}{p}\pi}{1+\cos\frac{p_n}{p}\pi}(\cos pt-\cos p_nt)}{\sin pt} \tag{8}$$

must hold for all values of t in the interval $0<t<\frac{\pi}{p}$ (assuming that $t=0$ at the beginning of the period for which the negative sign of F applies). If it can be shown now that the expression on the right-hand side of (8) is positive for any one value of t in the given interval, θ_0 must always be greater than such a value in order for (7) to apply and hence will always be positive. The existence of the value required may be shown by applying L'Hospital's Rule to the function for the case in which $t=0$ (which may be done since the function becomes indeterminate for this value of t). Upon doing this it is found that the limit $\frac{F}{pp_n}$ is approached by the function as t approaches zero from above. This, then, means that θ_0 can only be less than $\frac{F}{pp_n}$ by an infinitely small amount and the required value of the function is thus found to exist in the neighborhood of $t=0$.

If it is now assumed that equation (7) holds for all positions of the counterbalance except those eliminated by (8), it is evident that the slope of the curve so obtained will be positive on one side of the region for which (7) does not hold and negative on the other side of such a region. This indicates that a minimum value of θ_0 lies

within these regions and that the position of the counterbalance for which a minimum occurs is approximately that for which the last term of equation (7) becomes infinite. On the basis of this conclusion and with the use of the data for the theodolite previously mentioned the curves shown in figure 2 have been drawn to indicate the manner in which the counterbalance should be adjusted. It is evident from this figure that if the period of roll of the ship varies more than a second from the mean period for which the counterbalance has presumably been adjusted, the position of the counterbalance will then be in the neighborhood of that for a maximum instead of a minimum. That such a variation is of an extremely frequent occurrence is shown by an inspection of the record of the roll period of the U. S. S. *Pensacola* while she was underway in a calm sea in which a moderate swell existed. The mean period of roll for 155 observations was found to be 11.5 seconds and the average deviation from this mean was found to be 1.2 seconds. Hence, even with very nearly ideal conditions as far as the sea was concerned and with a 10,000-ton ship, the variation in the period of roll was found to be quite sufficient to give just about as many maximum amplitudes of oscillation as minimum amplitudes. It is then evident that for a free suspension of the theodolite, the position of the counterbalance is practically immaterial.

If, however, the device of connecting the counterbalance shaft to the tripod legs by light springs is employed (which device was mentioned in the previously quoted article by Signor Eredia and has also been in use by the United States Navy since 1928, or before) and an absence of pitching together with a fixity of the axis of roll with respect to the ship is assumed, verticality of the theodolite at the extreme of a given roll can be attained if springs of the proper stiffness are used and the counterbalance is properly adjusted. The stiffness of the springs to be used and the way in which the counterbalance adjustment should be made is derived from the following considerations.

The center of mass will still move toward the lower side of the ship in its rolling as before. A necessary condition that the center of mass of the theodolite should be at an extreme in this motion is that there should be equilibrium between the torques exerted by all the forces involved—i. e., between the torques exerted by the forces due to the spring, friction, gravity, and the inertia of the theodolite.

Assuming (1) that one leg of the tripod lies in a plane perpendicular to the roll axes, (2) that this leg is on the opposite side of the theodolite from the lower side of the ship in the roll considered, and (3) that the springs are taut but not extended when the deck is level and the counterbalance shaft is vertical; the torque exerted by the spring under tension is given by the expression

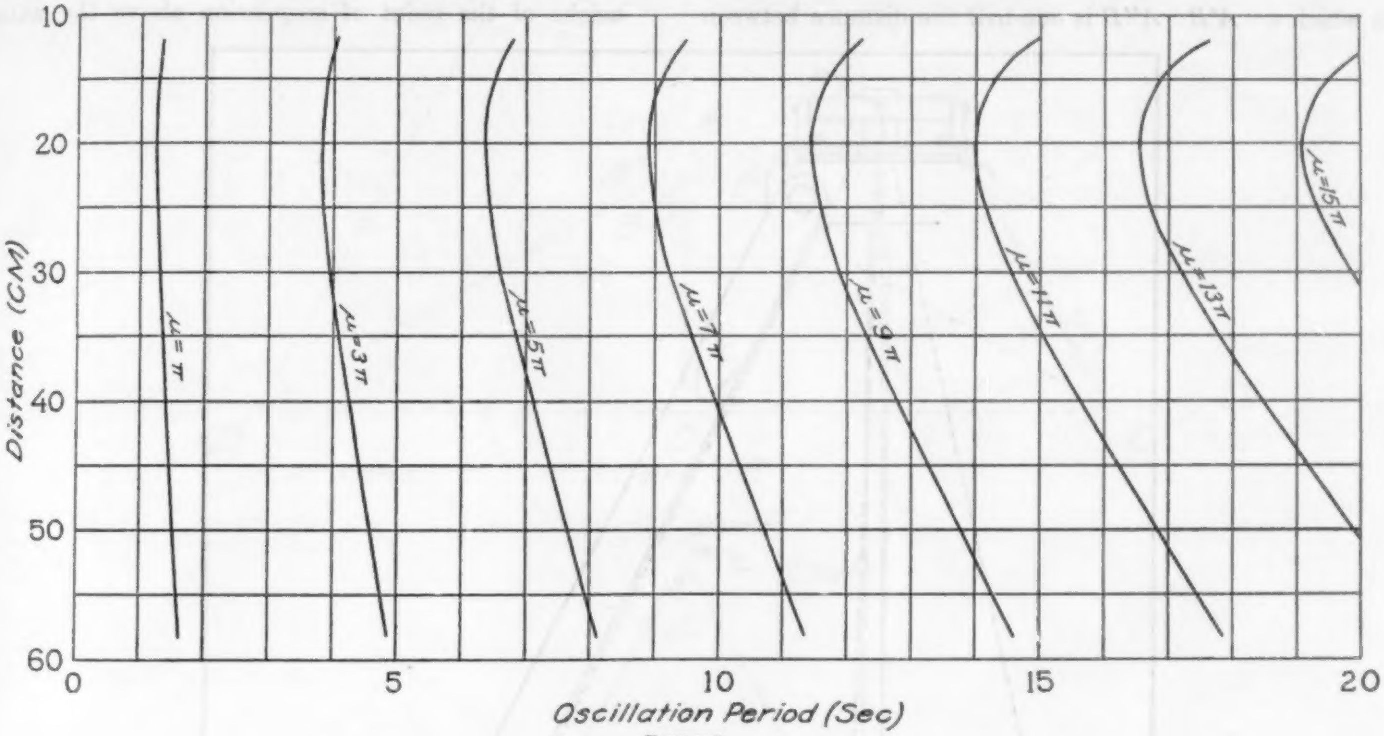

FIGURE 2.

$$kqw\,\frac{(z-r)}{z}\,\sin\,(\gamma+\Phi_0+\theta)$$

where, referring to figure 3:

$r=AC=$ the distance between the points of attachment of the spring to the counterbalance shaft and to the tripod leg respectively when the spring is unextended.

$q=CO=$ the distance of the point of suspension of the theodolite from the point of attachment of the spring to the tripod leg.

$w=AO=$ the distance of the point of suspension of the theodolite from the point of attachment of the spring to the counterbalance shaft.

$\gamma=\angle AOC=$ the angle formed at the point of suspension by straight lines through the points of attachment of the spring when the deck and tripod head are level and when the counterbalance shaft is vertical.

$z=$ the distance between the points of attachment of the spring at the instant considered.

$k=$ the stiffness of the spring.

For a roll in the opposite direction, the torque exerted by the two springs combined is given by the expression

$$2ksw\,\frac{(v-r)}{v}\,\sin\,(\alpha+\Phi_0+\theta)$$

in which, referring to figures (3) and (4),

$s=DO=$ the slant height of the pyramid formed by the point of suspension of the theodolite and the three points of attachment of the springs to the tripod legs.

$\alpha=\angle BOD=$ the angle formed by drawing lines from the point of suspension through the extremities of the altitude drawn through the midpoints of the parallel sides of the trapezoid formed by the four points of attachment of the springs concerned,

and v is given by the equation

$$v^2=a^2-2a\sqrt{q^2-s^2}+q^2+w^2-2ws\cos(\alpha+\Phi_0+\theta)$$

in which $a=A'B=A''B$ is one-half the distance between the two points at which the springs are attached to the counterbalance shaft.

The torque exerted by friction is, as has been mentioned previously, $L=K\times F=$const., K being the moment of inertia of the theodolite and F being the angular acceleration due to friction.

The torque due to the inertia of the theodolite is:

$$Mh\Phi_0Hp^2\cos(\Psi+\Phi_0+\theta)$$

where

$\Psi=$ the angle whose tangent is given by the ratio of the distance of the point of suspension from the medial plane of the ship (the plane which divides the ship longitudinally into two symmetrical parts) to the height of the point of suspension above the water

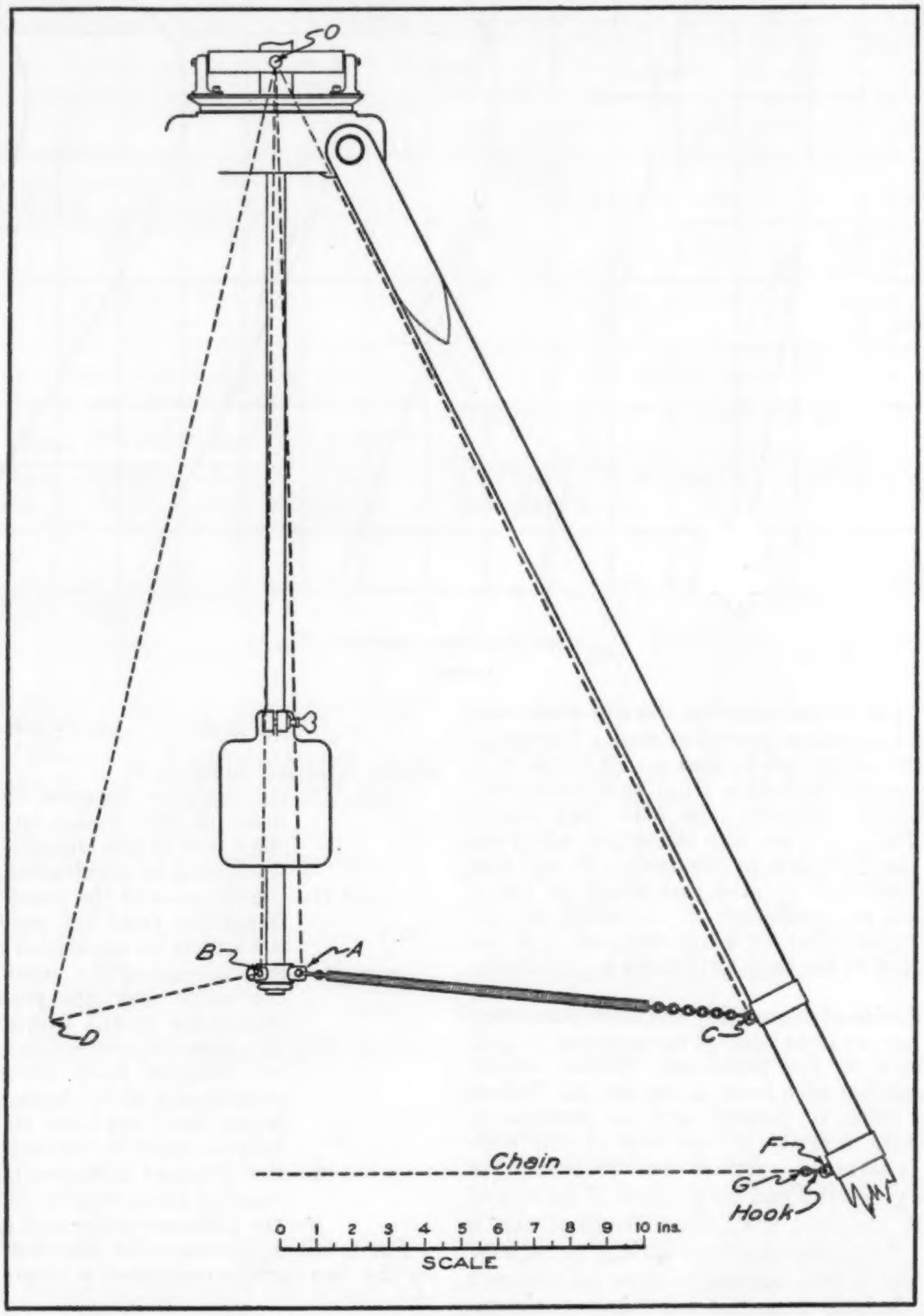

FIGURE 3.

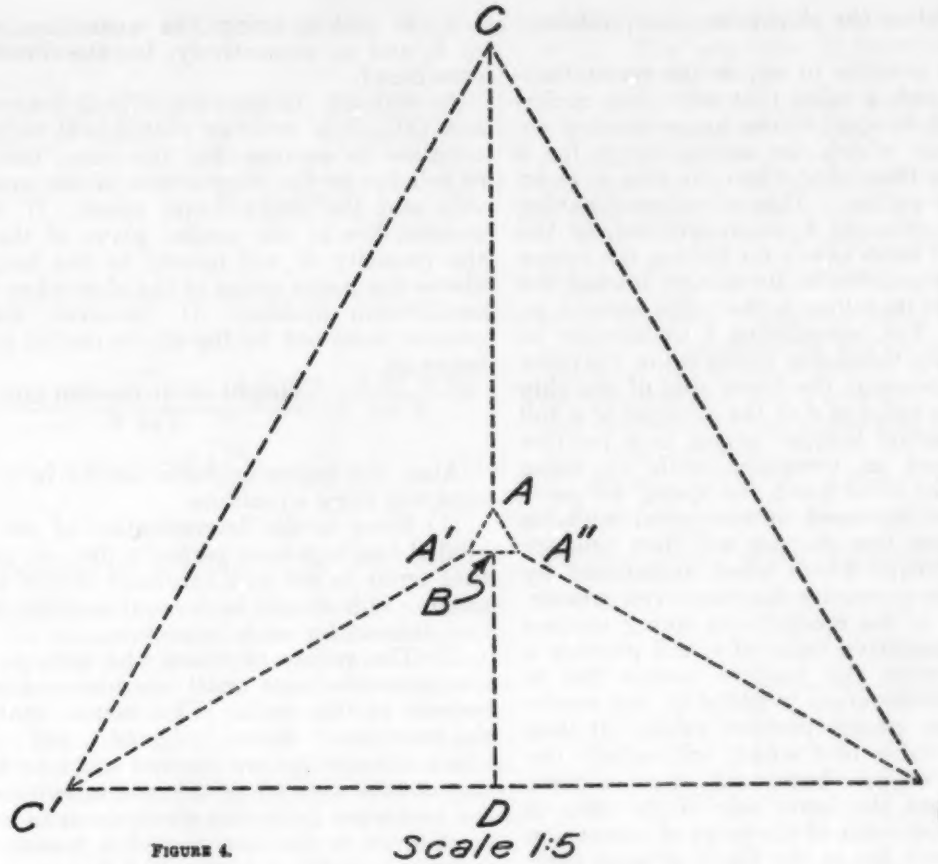

FIGURE 4.

FIGURE 5.

plane of the ship when the ship is in its equilibrium position.

Now it is evidently possible to adjust the counterbalance so that Mh has such a value that when it is multiplied by $H\Phi_0 p^2 \cos \Phi_0$ it is equal to the torque exerted by friction plus the torque which the spring exerts for a vertical position of the theodolite when the ship is in an extreme position in its rolling. This adjustment having been made, the only value of θ which will satisfy the necessary condition set forth above for having the center of mass at an extreme position in its motion toward the lower side of the ship in its rolling is the value zero—i. e., assuming that $\Psi=0$. For, considering θ to increase as the center of mass of the theodolite (lying below the point of suspension) moves towards the lower side of the ship in its rolling, a positive value of θ at the extreme of a roll will mean that the inertial torque—acting in a positive direction—has decreased as compared with its value when $\theta=0$, while, on the other hand, the spring torque—acting negatively—has increased as compared with its value when $\theta=0$. These two changes will then produce a resultant negative torque which when augmented by the negative torque due to gravity becomes even greater. Similarly, the changes in the inertial and spring torques caused by assuming a negative value of θ, will produce a positive torque and, when the positive torque due to gravity under these circumstances is added in, the resultant torque has an even greater positive value. It then follows that the only value of θ which will satisfy the required condition is, as has been said, that of zero. Therefore, assuming that the lower side of the ship in its rolling is on the opposite side of the point of suspension from the tripod leg which lies in the plane athwart ship, the torque equilibrium equation is:

$$Mh_0\Phi_0 Hp^2 \cos \Phi_0 = L + kqw\frac{(z_0-r)}{z_0} \sin (\gamma+\Phi_0) \qquad (9)$$

where

h_0 = the distance of the point of suspension from the center of mass of the theodolite corresponding to the required counterbalance adjustment.

and

z_0 = the distance between the points of attachment of the spring when the theodolite is vertical at the extreme of the roll.

Now $Mh_0 = M_2x_0 + M_1x_1$

where

M_2 = the mass of the counterbalance,

x_0 = the distance of the point of suspension from the center of mass of the counterbalance when the required adjustment is made,

M_1 = the mass of the part of the theodolite on gimbals less the mass of the counterbalance,

and

x_1 = the distance of the center of mass of M_1 from the point of suspension.

Therefore,

$$x_0 = \frac{kqw}{M_2\Phi_0 Hp^2 \cos \Phi_0} \cdot \frac{z_0-r}{z_0} \sin (\gamma+\Phi_0) + \frac{L}{M_2\Phi_0 Hp^2 \cos \Phi_0} - \frac{M_1x_1}{M_2} \qquad (10)$$

Similarly, for a roll in the opposite direction

$$x'_0 = \frac{2k'sw}{M_2\Phi_0 Hp^2 \cos \Phi_0} \cdot \frac{v_0-r}{v_0} \sin (\alpha+\Phi_0) + \frac{L}{M_2\Phi_0 Hp^2 \cos \Phi_0} - \frac{M_1x_1}{M_2}, \qquad (11)$$

x'_0, k' and v_0 being the quantities corresponding to x_0, k, and z_0, respectively, for the direction of roll first considered.

In deriving the quantity H which appears in both (10) and (11), it is believed that it will be found sufficiently accurate to assume that the mean position of the axes of roll lies at the intersection of the medial plane of the ship and the ship's water plane. If the point of suspension lies in the medial plane of the ship, therefore, the quantity H will merely be the height of this point above the water plane of the ship when the ship is in an equilibrium position. If, however, the point of suspension does not lie the ship's medial plane, H must be taken as

$$\frac{\text{Height of suspension point}}{\text{Cos } \Psi}$$

Also, the following facts are to be borne in mind in applying these equations:

(1) Since in the determination of the constant L, the gimbal bearings were perfectly dry, all traces of anything that tends to act as a lubricant should be removed from them. This should be done, if possible, by washing them in a solvent for such lubricants.

(2) The points at which the springs are attached to the counterbalance shaft are assumed to be fixed with respect to the shaft. This means that in the case of the instrument shown in figure 1, the movable ring into which the springs are hooked must be fixed so that the ring cannot slide along the counterbalance shaft. One of the best ways to do this would seem to be that of putting a set screw in the ring in such a manner that when it is tightened all sliding on the shaft is prevented.

To facilitate the application of equations (10) and (11), all necessary measurements have been made on an instrument of the type "Aero 1928" manufactured for the U. S. Navy. Since the instrument is equipped with an extension type tripod a fixed spread of the legs was arbitrarily adopted—it being assumed that the device of stretching a given length of chain between the tripod legs would be used to give the chosen amount of spread whenever the theodolite is set up. The spread adopted was a little less than 25°. Assuming that the three lengths of chain are connected by the closed ends of three small hooks which are furnished by the instrument manufacturer and which have the other ends attached to the tripod legs (as is shown in figures 3 and 5) the length of chain required for the adopted spread is 25.27 inches. This corresponds to the length of 128 links of the chain furnished by the manufacturer with the instrument. When this length of chain is used and the movable ring is clamped against the bottom flange of the counterbalance shaft, the constants used in equations (10) and (11) are found to have the following values:

$\alpha = \angle BOD = 13.29°$
$\gamma = \angle AOC = 24.65°$
$r = AC = 12.39$ in.
$w = AO = 24.92$ in.
$q = CO = 29.28$ in.
$s = DO = 27.01$ in.
$a = A'B = A''B = 0.68$ in.
$x_1 = -0.15$ in. (the minus sign meaning that the center of mass of M_1 lies *above* the point of suspension)

$M_1 = 10.01$ lb.
$M_2 = 8.93$ lb.
$L = 5.05$ lb. ft. in. sec.$^{-2}$

Substituting these values of the constants in equations (10) and (11) there results:

$$x_0-0.17\text{ in.}=2.070k\left(\frac{T^2}{H}\right)\frac{z_0-12.39}{z_0}\frac{\sin(24.65°+\Phi_0)}{\Phi_0\cos\Phi_0}+1.432\times10^{-2}\left(\frac{T^2}{H}\right)\frac{1}{\Phi_0\cos\Phi_0}\qquad(10a)$$

where

$$z_0=[1478.4349-1459.3152\cos(24.65°+\Phi_0)]^{1/2}$$

and

$$x_0'-0.17\text{ in.}=3.819k'\left(\frac{T^2}{H}\right)\frac{v_0-12.39}{v_0}\frac{\sin(13.29°+\Phi_0)}{\Phi_0\cos\Phi_0}+1.432\times10^{-2}\left(\frac{T^2}{H}\right)\frac{1}{\Phi_0\cos\Phi_0}\qquad(11a)$$

where

$$v_0=[1463.6445-1346.1748\cos(13.29°+\Phi_0)]^{1/2}$$

In order to apply these equations it is further necessary to know where the center of mass of the counterbalance is with reference to, say, the top of the counterbalance, and it is also necessary to know how far some convenient reference point on the theodolite proper is from the point of suspension. The distance of the counterbalance's center of mass from the top of the ring which serves to clamp it to the shaft was found to be 2.53 in. The distance of the counterbalance shaft flange which serves to limit the upward motion of the counterbalance from the point of suspension was found to be 2.22 in. If, therefore, it is desired to use a value of x of, say, 10 inches, the counterbalance would be lowered (10.00−2.22−2.53) in. = 5.25 in. from the uppermost position which it is possible for it to have on the shaft.

To further facilitate the application of these equations to this instrument the table given below has been worked out in the following manner:

An inspection of equations (10a) and (11a) shows that both $x_0+\frac{M_1x_1}{M_2}$ and $x_0'+\frac{M_1x_1}{M_2}$ are directly proportional to $\frac{T^2}{H}$. The factors of proportionality are seen to be composed of two terms. Let the first term of the proportionality factor in equation (10a) be represented by

$$A=k\left[\frac{2.070(z_0-12.39)\sin(24.65°+\Phi_0)}{z_0\Phi_0\cos\Phi_0}\right]$$

and the first term of the proportionality factor in equation (11a) be represented by

$$A'=k'\left[\frac{3.819(v_0-12.39)\sin(13.29°+\Phi_0)}{v_0\Phi_0\cos\Phi_0}\right]$$

The second terms of the two factors of proportionality are seen to be identical and will be represented by

$$B=\frac{1.432\times10^{-2}}{\Phi_0\cos\Phi_0}$$

Now the proportionality factor to be used in obtaining the required adjustment of the counterbalance is evidently the mean of the two proportionality factors for $x_0+\frac{M_1x_1}{M_2}$ and $x_0'+\frac{M_1x_1}{M_2}$. This mean can, of course, be obtained by adding the mean of the values of A and A' to the value of B. This operation is provided for as follows in the table mentioned:

A set of six spaces has been provided for each whole degree of value of Φ_0 from 1° to 24° inclusive. These six spaces are numbered as is shown in figure 6 and the data intended to be used in these spaces are those indicated in this figure. Hence in order to obtain the required value of the proportionality factor to be used in obtaining $\frac{x_0+x_0'}{2}+\frac{M_1x_1}{M_2}$ for a given angle, the product of the datum given in space 1 and the value of k used is entered in space 4, the product of the datum given in space 2 and the value of k' used is entered in space 5, the mean of the data in spaces 4 and 5 is added to the datum in space 3 and the result of the addition is entered in space 6. It is then only necessary to multiply the datum in space 6 by the proper value of T^2/H and subtract (algebraically) the value of $\frac{M_1x_1}{M_2}$ from this product in order to obtain the required setting of the counterbalance.

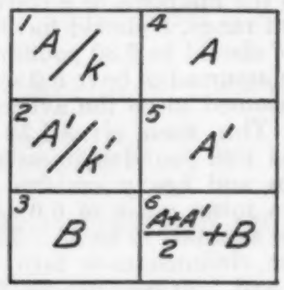

FIGURE 6.

TABLE 1

1°		2°		3°		4°	
1.505 0.959 0.820	----- ----- -----	1.628 1.034 0.410	----- ----- -----	1.672 1.104 0.274	----- ----- -----	1.696 1.176 0.206	----- ----- -----
5°		**6°**		**7°**		**8°**	
1.713 1.244 0.165	----- ----- -----	1.726 1.311 0.137	----- ----- -----	1.736 1.377 0.118	----- ----- -----	1.744 1.440 0.104	----- ----- -----
9°		**10°**		**11°**		**12°**	
1.752 1.503 0.092	----- ----- -----	1.759 1.563 0.083	----- ----- -----	1.765 1.622 0.076	----- ----- -----	1.771 1.679 0.070	----- ----- -----
13°		**14°**		**15°**		**16°**	
1.777 1.734 0.065	----- ----- -----	1.782 1.788 0.060	----- ----- -----	1.788 1.841 0.057	----- ----- -----	1.793 1.893 0.053	----- ----- -----
17°		**18°**		**19°**		**20°**	
1.799 1.943 0.050	----- ----- -----	1.805 1.992 0.048	----- ----- -----	1.810 2.039 0.046	----- ----- -----	1.816 2.086 0.044	----- ----- -----
21°		**22°**		**23°**		**24°**	
1.822 2.132 0.042	----- ----- -----	1.829 2.178 0.040	----- ----- -----	1.836 2.222 0.039	----- ----- -----	1.842 2.266 0.037	----- ----- -----

In computing the quantities given in spaces 1, 2, and 3, the British Absolute system of units has been used, i. e., the unit of mass is the pound and the unit of force is the poundal. Hence, the stiffnesses k and k' are to be determined in poundals per inch, i. e., the stiffness of a spring is found by observing the number of inches of elongation l produced when a mass of m pounds is suspended from it and then multiplying the quantity m/l by the acceleration of gravity, 32.2 ft. sec.$^{-2}$. In determining the value of T^2/H to be used, T is to be measured in seconds and H is to be measured in feet.

Regarding the computation of the proper spring stiffnesses, the guiding principle is to select springs of such stiffness that the counterbalance will be approximately at the mid-point of a convenient adjustment range for the average conditions aboard the ship to be used, and also to select them in such a way that x_0 and x_0' will agree for these prevailing conditions. These computations have been carried out for three types of ships: destroyers, cutters, and battleships or heavy cruisers. For destroyers T^2/H has been assumed to have a value of 1.5 sec^2/ft. and 8° has been chosen as the average value of Φ_0. Selecting $x=15.34$ inches as the midpoint of a convenient counterbalance adjustment range, k should have a value of 5.21 poundals/in. and k' should be 6.30 poundals/in. For cutters T^2/H has been assumed to have 6.0 sec.^{2}/ft. as a mean value and 8° is assumed to be the average amplitude of roll encountered. This, then, gives 1.39 poundals/in. as the value for k and 1.68 poundals/in. as the value for k'. Aboard battleships and heavy cruisers T^2/H has been assumed to have a mean value of 6.0 sec.^{2}/ft. while the mean value of Φ_0 is assumed to be 5°. The required stiffnesses under these circumstances turn out to be 1.38 poundals/in. for k and 1.90 poundals/in. for k'.

An inspection of table 1 will show that for rolling in the neighborhood of 14°, k and k' should have the same value in order to produce good agreement between A and A'. Assuming the same values of T^2/H as before, k and k' should both, therefore, have the value of 5.21 poundals/in. when $10°<\Phi_0<17°$ aboard destroyers. Aboard cutters, their common value will be 1.39 poundals/in. when $10°<\Phi_0<17°$, and aboard battleships and heavy cruisers this common value will be 1.38 poundals/in. when $8°<\Phi_0<17°$. Should the mean amplitude of roll equal or exceed 17°, k' should be given the values 5.21, 1.39, and 1.38 poundals/in. for destroyers, cruisers, and battleships, respectively, while the corresponding values of k will be 5.87, 1.57, and 1.55 poundals/in., respectively.

Except when expressly stated otherwise, it has been assumed in the whole of the foregoing calculations that $\Psi=0$. When this is not the case, the factor $\cos\Phi_0$ appearing in the denominators of the terms on the right hand sides of both equations (10) and (10a) should be replaced by $\cos(\Phi_0-\Psi)$ while this factor in the denominators of the terms on the right hand sides of (11) and (11a) should be replaced by $\cos(\Phi_0+\Psi)$, i. e. assuming that the "athwart ship leg" of the tripod has been placed outboard. To better the agreement between x_0 and x'_0 under these circumstances, the value of k to be used should be taken from the formula

$$k=\frac{1}{(A/k)}\left[\frac{15.17\cos(\Phi_0-\Psi)}{(T^2/H)\cos\Phi_0}-B\right]$$

and the value of k' should be taken from the formula

$$k'=\frac{1}{(A'/k')}\left[\frac{15.17\cos(\Phi_0+\Psi)}{(T^2/H)\cos\Phi_0}-B\right]$$

In these formulae both A/k and A'/k' are regarded as constants, whose value, along with that of B is to be obtained from spaces 1, 2, and 3, respectively, in table 1.

Assuming that the springs having the stiffnesses given by the above formulae have been supplied, spaces (4) and (5) of Table 1 are then to be filled in using these values of k and k'. Next $\frac{H}{T^2}\left(x_0+\frac{M_1x_1}{M_2}\right)$ must be found by adding B, the datum in space (3), to A, the datum in space (4), and then multiplying the result by $\frac{\cos\Phi_0}{\cos(\Phi_0-\Psi)}$. Similarly $\frac{H}{T^2}\left(x_0'+\frac{M_1x_1}{M_2}\right)$ must be found by adding A' to B and multiplying the result by $\frac{\cos\Phi_0}{\cos(\Phi_0+\Psi)}$. The mean of the values $\frac{H}{T^2}\left(x_0+\frac{M_1x_1}{M_2}\right)$ and $\frac{H}{T^2}\left(x_0'+\frac{M_1x_1}{M_2}\right)$ is then, of course, equal to $\frac{H}{T^2}\left(\frac{x_0+x_0'}{2}+\frac{M_1x_1}{M_2}\right)$, the datum to be put in space (6), and the remainder of the procedure is the same as that for the case when $\Psi=0$.

To illustrate the various ways in which table 1 is to be used, the following examples are given:

(1) Suppose that the point of suspension of a theodolite set up on board a battleship lies in the medial plane of the ship and 40 feet above the water plane and that the mean period of roll is 16.2 seconds, the mean amplitude of roll is 6° and that, consequently, the stiffnesses of the springs being used are $k=1.38$ poundals/in. and $k'=1.90$ poundals/in. The entry for space 4 of the 6° section of table 1 is then $1.726\times1.38=2.38$. The entry in space 5 will be the product of 1.311 and 1.90 or 2.49. The mean of these two products is 2.44. Adding this mean to the datum in space 3 we have 2.58 as the entry for space 6 and the completed section of the table for the roll amplitude of 6° will then read

6°	
1.726	2.38
1.311	2.49
0.137	2.58

Hence the required counterbalance adjustment will be

$$\frac{(16.2)^2}{40.0}\times2.58-(-0.17)=17.1\text{ in.}$$

This means that the counterbalance will be lowered

$$17.1-(2.2+2.5)=17.1-4.7=12.4\text{ in.}$$

from the topmost position which it is possible for it to have on the shaft (any limitation to the motion of the counterbalance along the shaft furnished by the interference of the tripod legs is not, of course, to be considered in making this adjustment).

(2) Suppose, next, that all conditions are the same as those stated in the first example with the exception that the point of suspension has been moved 30 feet from the medial plane of the ship (the value of Φ being, consequently, $\tan^{-1}\frac{30}{40}=36.9°$ instead of zero as was the case in the first example) and that the spring stiffnesses are, therefore, different from those used in the first example. Assuming that the athwart ship

leg of the tripod (to which the spring with the stiffness k is attached) has been placed outboard and assuming, further, that the same average values of Φ_0 and T^2/H as were used in computing the spring stiffnesses when the point of suspension lay in the ship's medial plane are to be used in computing the spring stiffnesses in this case, we have for the values of these spring stiffnesses:

$$k=\frac{1}{1.713}\,\frac{15.17\times\cos\,(5-36.9)^\circ}{6.00\,\cos\,5^\circ}-0.165$$
$$=1.16\text{ poundals/in.}$$

and

$$k'=\frac{1}{1.244}\,\frac{15.17\,\cos\,(5+36.9)^\circ}{6.00\times0.9962}-0.165$$
$$=1.39\text{ poundals/in.}$$

The datum entered in space 4 will then be $1.16\times1.726=2.00$. That to be entered in space 5 will be $1.39\times1.311=1.82$. For the value of $\frac{H}{T^2}\left(x_0+\frac{M_1x_1}{M_2}\right)$ we have:

$$(2.00+0.137)\,\frac{\cos\,6^\circ}{\cos\,(6^\circ-36.9^\circ)}=2.48$$

and for the value of $\frac{H}{T^2}\left(x_0+\frac{M_1x_1}{M_2}\right)$ we have:

$$(1.82+0.137)\,\frac{\cos\,6^\circ}{\cos\,(6^\circ+36.9^\circ)}=2.66$$

Hence for the datum to be entered in space 6 we take the mean of 2.48 and 2.66 which is 2.57. The completed section for the 6° amplitude of roll then reads:

6°	
1.726 1.311 0.137	2.00 1.82 2.57

Multiplying the datum in space 6 by T^2/H and subtracting the value of $\frac{M_1x_1}{M_2}$, we have

$$\frac{2.57\,(16.2)^2\cos\,36.9^\circ}{40}-(-0.17)=13.7\text{ in.}$$

as the required counterbalance adjustment. As before, this means that the counterbalance must be lowered $13.7-4.7=9.0$ in. from its topmost position on the shaft.

In figure 3 it will be noticed that instead of having only a spring stretching between A and C, a spring with a short piece of chain attached to it is stretched between these two points. If the spring is fastened to the counterbalance shaft, and the chain is fastened to the tripod leg, this arrangement will eliminate any torques that might arise on account of the buckling of the springs. Furthermore, the part of the distance covered by the length of the spring should be very nearly the same as that shown in the figure. This is true because a spring whose length is much greater than that shown will buckle for large swings of the theodolite, while the elastic limit of a spring which is very much shorter than the one shown is more apt to be exceeded for large swings of the theodolite than is the case for the longer spring. Hence if 10 links of the kind of chain furnished by the manufacturer for limiting the spread of the tripod legs is used with a spring 9.22 in. long (9.22 in. is the distance between the inside edges of the spring couplings when the spring is unstretched), the combined length of the spring and chain assembly (including the length of the two hooks which are linked with the eyelets at A and C) will be equal to 12.39 in.—which is the length of AC required.

In order to secure springs of the proper length and stiffness it will, in general, be necessary to make use of the formula giving the stiffness of a closed coil helical spring. This formula is

$$k=\frac{d^4G}{64np^3}$$

where d is the diameter in inches of the wire used, G is the coefficient of rigidity in poundals per square inch, n is the number of turns used and p is the mean radius of the coil in inches. If phosphor-bronze (the alloy usually used in making such springs) is used, G has the value 1.996×10^7 poundals per square inch.

Finally, the effects on the motion of the theodolite of variations of T and Φ_0 from the assumed mean values may be determined. In order to do this it is necessary to make use of the more general torque equations, i. e., those equations which allow for other values of θ than that of zero. These equations are:

$$kqw\frac{z-r}{z}\sin(\gamma+\Phi_0+\theta)+Mgh\,\sin\,\theta+L$$
$$=Mh\Phi_0H\frac{4\pi^2}{T^2}\cos\,(\Psi+\Phi_0+\theta) \tag{14}$$

where

$$z=[q^2+w^2-2qw\,\cos(\gamma+\Phi_0+\theta)]^{1/2}$$

and

$$2k'sw\frac{(v-r)}{v}\sin(\alpha+\Phi_0+\theta)+Mgh\,\sin\,\theta+L$$
$$=Mh\Phi H\frac{4\pi^2}{T^2}\cos\,(\Psi+\Phi_0+\theta) \tag{15}$$

where

$$v=[a^2-2a\sqrt{q^2-s^2}+q^2+w^2-2ws\,\cos(\alpha+\Phi_0+\theta)$$

It is at once evident that it would be very difficult to solve these equations for θ_0 using T and Φ_0 as the independent variables. θ and Φ_0 can, however, be used as independent variables and the corresponding values of T ascertained. Using a mean period of $T=15.58$ sec. and a value of 5° for the mean value of Φ_0, the values of T which will give −3°, −2°, −1°, 0°, 1°, 2°, and 3° as values of θ have been computed for each of the cases in which Φ_0 takes on the values of 5°, 9°, 13°, 17°, and 19°—this being done both for the case where the single spring is being stretched and also for the case where the two springs are being stretched, and the resulting values of T being designated as T' and T'' respectively.[3] Using the same assumed period (15.58 sec.) but a value of 9° for the mean value of Φ_0, the values of T which will cause θ to vanish when $\Phi_0=5°$, 9°, 13°, 17°, and 19° have also been computed. This latter set of computations has also been carried out for the case in which the counterbalance has been adjusted for 17° as a mean value of Φ_0. Also the values of T, which will give −3°, 0°, and +3° as values of θ when mean values of T and Φ_0 of 15.58 sec. and 19°, respectively, are assumed, have been computed for the cases in which Φ_0 takes on the values 5°, 9°, 13°, 17°, and 19°. Finally, assuming a mean value of $T=11.5$ sec. and 5° as a mean value of Φ_0, the values of T which will give −3° and +3° as values of θ have been computed for the 5°, 9°, 13°, 17°,

[3] Ψ was arbitrarily given the value zero in these computations, as well as in all the computations succeeding them.

and 19° values of Φ_0. The results of all of these computations are shown in the following tables:

TABLE 2

Assumed mean values: $\Phi_0=5°$, $T=15.58$ sec.						
	Φ_0	5°	9°	13°	17°	19°
$\theta=+3°$	T'	7.28	8.98	10.02	10.71	10.97
	T''	7.12	8.44	9.06	9.32	9.38
$\theta=+2°$	T'	8.47	10.20	11.19	11.81	12.04
	T''	8.32	9.58	10.03	10.16	10.17
$\theta=+1°$	T'	10.53	12.09	12.87	13.31	13.46
	T''	10.40	11.30	11.41	11.27	11.16
$\theta=0°$	T'	15.58	15.64	15.61	15.56	15.53
	T''	15.58	14.90	13.51	12.74	12.51
$\theta=-1°$	T'	--------	27.20	21.41	19.49	19.41
	T''	--------	23.38	17.40	15.16	14.45
$\theta=-2°$	T'	--------	--------	59.51	29.51	26.25
	T''	--------	--------	29.34	19.50	17.64
$\theta=-3°$	T'	--------	--------	--------	--------	89.51
	T''	--------	--------	--------	32.64	24.52

TABLE 3

Assumed mean values: $\Phi_0=9°$, $T=15.58$ sec.						
	Φ_0	5°	9°	13°	17°	19°
$\theta=0°$	T'	14.98	15.24	15.10	14.97	14.93
	T''	17.37	16.18	15.19	14.68	14.08

TABLE 4

Assumes mean values: $\Phi_0=17°$, $T=15.58$ sec.						
	Φ_0	5°	9°	13°	17°	19°
$\theta=0°$	T'	15.48	15.51	15.48	15.42	15.39
	T''	18.94	17.66	16.57	15.72	15.37

TABLE 5

Assumed mean values: $\Phi_0=19°$, $T=15.58$ sec.						
	Φ_0	5°	9c	13°	17°	19°
$\theta=+3°$	T'	7.28	9.00	10.04	10.73	10.99
	T''	7.63	9.31	10.19	10.67	10.81
$\theta=0°$	T'	15.68	15.71	15.67	15.62	15.59
	T''	19.23	17.88	16.79	15.93	15.56
$\theta=-3°$	T'	--------	--------	--------	--------	101.05
	T''	--------	--------	--------	--------	--------

TABLE 6

Assumed mean values: $\Phi_0=5°$, $T=11.5$ sec.						
	Φ_0	5°	9°	13°	17°	19°
$\theta=+3°$	T'	6.41	7.68	8.39	8.84	9.00
	T''	6.21	7.08	7.39	7.47	7.53
$\theta=-3°$	T'	--------	--------	31.61	19.84	18.20
	T''	--------	--------	21.08	14.42	13.08

5° and 19° were selected as mean values of Φ_0 in these computations since, with the use of the method of selecting spring stiffnesses previously outlined, x_0 and x'_0 agree for these mean values of Φ_0. Similarly 9° and 17° were also selected as mean values of Φ_0 due to the fact that x_0 and x'_0 differ most for these mean values of Φ_0 when the spring stiffnesses just mentioned are used. $-3°$ and $+3°$ were selected as limiting values of θ because the theodolite for which these computations apply has a field of view of 6° and any greater values of θ (taken absolutely) would, of course, carry the balloon out of this field.

It will be noted that no value of T' or T'' is given for a good many cases where θ was assumed to have a negative value. If, for instance, equation (14) is solved for T^2, the expression representing its value will be a fraction having the coefficient of $\frac{1}{T^2}$ in equation (14) as the numerator and the left-hand side of (14) will constitute the denominator. Whenever the denominator of this fraction took on a negative value the omissions just referred to were made. This was done because the values of T in these cases became imaginary unless $\cos\ (\Psi+\Phi+\theta)$ became negative in the numerator. Since, if for no other reason, the mechanical arrangement of the theodolite would prevent this, it was not thought worth while to finish the computations for these negative denominator values.

An inspection of these tables shows that for $\theta=0°$, T' in contrast to T'', remains practically constant throughout the whole of the range of the values of Φ_0 chosen—this being true regardless of the assumed mean value of Φ_0. It will further be seen that, as was to be expected, these values of T' differ more from the assumed values of T for $\Phi_0=9°$ and $\Phi_0=17°$ than is the case for the assumed values $\Phi_0=5°$ and $\Phi_0=19°$—the error being due, of course, to the fact that the counterbalance setting corresponds to the mean of the values of x_0 and x'_0 and to the fact that these two quantities differ most when the assumed mean values of Φ_0 are 9° and 17° respectively. In view of these two facts then, it is apparent that the substitution of a second spring lying in the athwartship plane of the ship for the two springs not lying in that plane would greatly improve the results secured. A very simple way to construct a spring and chain assembly of this kind is to fasten the chain end to a ring or toroid which can in turn be fastened to the tripod by resting it on the tripod legs and providing stops to prevent its sliding up the legs. Since considerable work is involved in preparing tables similar to table 1, it will, of course, be advantageous to design this ring and to locate the stops in such a way that the triangles formed by the point of suspension and the pivoting points of the spring and chain assembly are congruent to the corresponding triangle shown in figure 3. Should it be desired to use a device of this kind, the necessary trigonometrical calculations for its design have been carried out and may be had upon request.

Furthermore if such a two-spring assembly is used instead of the usual three-spring assembly, tables 2 and 5 in conjunction with the roll record of the U. S. S. *Pensacola* previously referred to indicates the possibility of a considerable reduction in the optical field of the theodolite together with the consequent possibility of an increase in the theodolite's magnification. To see this, reference need only be made to figure 7. In this figure the curves marked $\theta=1°$, 2°, 3°, $-1°$ and $-2°$ indicate the amplitudes and periods necessary to produce the designated values of θ when (1) the two-spring assembly described above is used, (2) T is assumed to have a mean value of 11.5 sec., and (3) the mean value of Φ_0 is assumed to be 3°. The scattered points in the figure indicate the values of the various amplitudes and periods of roll observed aboard

the *Pensacola* in the set of observations previously referred to.[3] When it is now considered that the natural period of roll of the *Pensacola* is 11.5 sec., it will be seen that a fact which is known to those familiar with the behavior of ships at sea is well illustrated here, i. e., that, excluding storm conditions, virtually all heavy rolling has a period which is closely coincident with the natural period of roll. If, therefore, the natural period of roll is used in obtaining the counterbalance adjustment from table 1 instead of the average period as obtained from timing a comparatively small number of rolls of the ship (which may, of course, differ considerably from the natural period), the large amplitudes of roll of the ship will have very little effect on the verticality of the theodolite.[4] When this fact is considered along with the fact that of the 155 amplitudes and periods of roll observed, not a single roll was sufficient to produce a 1° deviation of the theodolite from the vertical under the circumstances described above, the possibilities as to the reduction of the field of view of the theodolite along with the consequent increase in magnification are evident. It seems quite possible, in fact, that the 20 power magnification possessed by the ordinary "shore" theodolite may, under these circumstances, be available for use in the shipboard theodolite since such an increase in magnification would only mean that the field of view of the shipboard theodolite would have to be reduced from 6° to 2.4°.

Summing up then, under the assumptions made it has first been shown that, due to the scattering of the periods of roll depicted in figure 7, the position of the counterbalance with the theodolite swinging free is immaterial. Secondly, under somewhat more general assumptions it has further been shown that it is possible to obtain a fairly satisfactory amount of stability for the theodolite by connecting the end of the counterbalance shaft to the tripod legs with light springs and coordinating the adjustment of the counterbalance with the stiffnesses of the springs used. Finally, using the same set of more general assumptions, it has also been shown that a much more satisfactory amount of stability can be secured by using two springs instead of three to counteract the inertial torque on the theodolite and that it seems probable that this stability will be sufficiently great to warrant a considerable decrease in the theodolite's field of view along with a corresponding increase in the magnification secured.

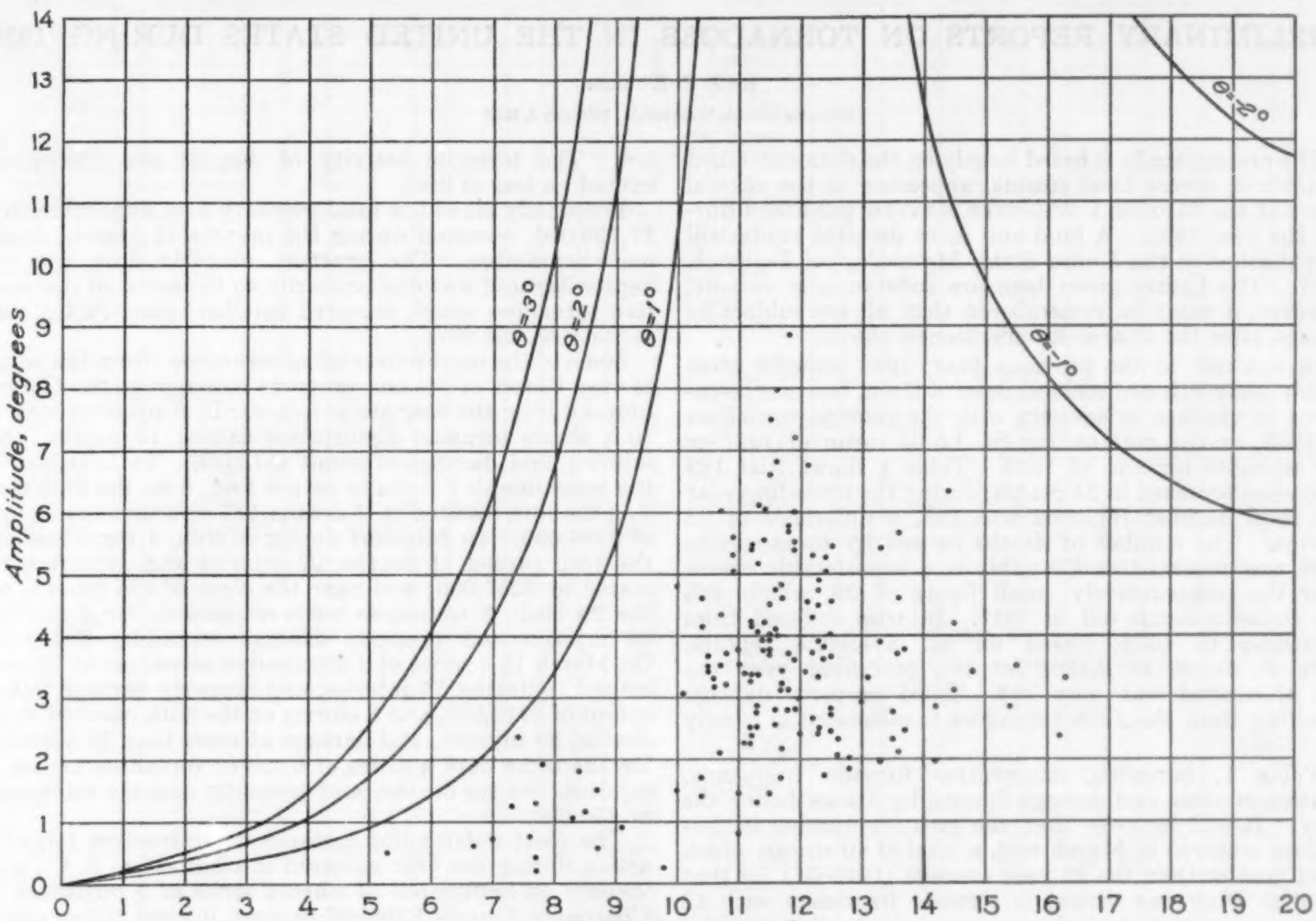

FIGURE 7.

[3] These data are published with the kind permission of the Chief of the Bureau of Construction and Repair of the Navy Department.

[4] It is evident that, under these circumstances, the obtaining of the proper counterbalance adjustment is greatly simplified. For T being taken as a constant for a given ship and H being taken as a constant for any one position of the theodolite on the ship, the counterbalance adjustments themselves may be entered in space 6 of the amplitude of roll sections of table 1 and, hence, a simple reference to the table thus filled in will replace the computations previously indicated.

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PRELIMINARY REPORTS ON TORNADOES IN THE UNITED STATES DURING 1938

By J. P. KOHLER

[Weather Bureau, Washington, February 2, 1939]

The present study is based largely on the data contained in table 3, severe local storms, appearing in the several issues of the MONTHLY WEATHER REVIEW published during the year 1938. A final and more detailed study will be published in the *United States Meteorological Yearbook, 1938*. The figures given here are substantially correct; however, it must be remembered that all are subject to change after the final study mentioned above.

In contrast to the previous year, 1938 brought some highly destructive tornadoes; none of them, however, compared in violence or severity with the Georgia tornadoes of 1936, or the outstanding St. Louis storm of 1927 or the tri-State tornado of 1925. Table 1 shows that 189 tornadoes occurred in 25 States; during the preceding year the total number reported was 123, a difference of 66 storms. The number of deaths caused by tornadoes in 1938 was reported as 178; this is a considerable excess over the comparatively small figure of 29, which was the tornado death toll in 1937. Injuries suffered from tornadoes in 1938, based on all available reports, were in excess of 2,189; for the preceding year the list of injured was only 192. Total property damage resulting from the 1938 tornadoes is estimated at nearly $8,000,000.

Table 1, herewith, enumerates tornado frequency, deaths, injuries, and damage figures, by States during the year. It will be seen that the greatest number of tornadoes occurred in March with a total of 60 storms which is 44 greater than the 22-year average (1916–37) for that month. May was second in tornado frequency with 42 storms, an excess of 11 above normal; in April there were 26 or 3 more than normal. Thirteen tornadoes occurred in July, 8 each in August, September, and November, 2 in February, and 1 in December. October was the only month in which no storm of even possible tornadic character was reported.

The greatest loss of life resulting from tornadoes during the year occurred in March when 74 deaths were reported. There were 32 deaths in September, 21 in February, 17 in April, 15 in May, 14 in June, 3 in July, and 2 in November. The tornadic activity of August and December caused no loss of life.

Practically all of the total property loss, approximately $7,790,000, occurred during the months of March, June, and September. The greatest monthly loss was in September and was due primarily to the series of destructive tornadoes which occurred in Charleston, S. C., and vicinity on the 29th.

Some of the most outstanding tornadoes (from the point of view of loss of life and property damage) in the United States during the year are as follows: In Kansas on March 10 a single tornadic disturbance caused 10 deaths, 150 injuries, and damage of about $575,000. In Arkansas in the same month 1 tornado on the first, 4 on the 28th and 9 on the 30th resulted in 18 deaths, 287 injuries and damage of $366,000. In Missouri during March, 4 tornadoes on the 15th caused 11 deaths, 27 injuries and damage estimated at $257,000; and near the close of the month, on the 29–30th, 8 tornadoes were responsible for 5 deaths. 56 injuries and property damage exceeding $224,000. On March 15 a series of 3 destructive tornadoes in Illinois caused 10 deaths, 77 injuries, and property damage to the extent of $215,000, and 3 storms on the 30th resulted in 13 deaths, 89 injuries, and damage of more than $1,500,000. On the same date a series of 6 minor tornadoes caused 4 injuries, but no deaths, and property damage estimated at $59,000.

The most outstanding instance of destructive tornadic action during the year occurred in Charleston, S. C., and vicinity on September 29 when a series of 5 tornadoes in Charleston County killed 32 persons, injured 150 or more, and damaged property to the estimated extent of $2,000,000. In this connection it may be stated that this is the greatest loss of life and property caused by tornadoes within a restricted area in that State during the period for which records are available.

In the event that the possible tornadoes enumerated in Table 2 are later adjudged to be true tornadoes, the 1938 figures will be 200 tornadoes, 181 deaths, 1,321 injuries, and property losses exceeding $8,045,000. (See tables 1 and 2 on pp. 413–414.)

TABLE 1.—*Tornadoes and probable tornadoes*

State	January	February	March	April	May	June	July	August	September	October	November	December	Year
ALABAMA:													
Number	0	0	9	2	0	0	0	0	0	0	0	0	11
Deaths			2	10									12
Injuries			55	75									130
Damage ($×1,000)			50.0	100.0									150.0
ARKANSAS:													
Number	0	0	14	0	5	0	0	0	0	0	1	0	20
Deaths			18		2						0		20
Injuries			287		20						0		307
Damage ($×1,000)			366.0		46.6						0.5		413.1
COLORADO:													
Number	0	0	0	1	1	0	0	0	0	0	0	0	2
Deaths				0	0								0
Injuries				0	0								0
Damage ($×1,000)				(3)	25.0								[9] 25.0
FLORIDA:													
Number	0	0	0	1	1	0	2	0	0	0	0	0	4
Deaths				0	0		0						0
Injuries				0	0		0						0
Damage ($×1,000)				0.3	0.2		(6)						[9] 0.5
GEORGIA:													
Number	0	0	0	3	0	0	0	0	0	0	0	0	3
Deaths				1									1
Injuries				2									2
Damage ($×1,000)				30.0									30.0
IDAHO:													
Number	0	0	0	0	0	0	1	0	0	0	0	0	1
Deaths							0						0
Injuries							0						0
Damage ($×1,000)							0.5						0.5
ILLINOIS:													
Number	0	0	12	0	0	2	2	0	0	0	0	0	16
Deaths			23			0	0						23
Injuries			170			0	0						170
Damage ($×1,000)			2,064.0			1.0	43.7						2,108.7
INDIANA:													
Number	0	0	0	0	3	0	1	2	0	0	0	0	6
Deaths					0		0	0					0
Injuries					0		0	0					0
Damage ($×1,000)					312.0		2.0	(7)					[9] 314.0
IOWA:													
Number	0	0	1	0	1	0	2	0	0	0	0	0	4
Deaths			0		0		0						0
Injuries			14		0		0						14
Damage ($×1,000)			8.0		7.0		[2] 0.4						[9] 15.4
KANSAS:													
Number	0	0	3	7	9	9	0	0	1	0	0	0	29
Deaths			11	0	6	0			0				17
Injuries			167	1	23	5			0				196
Damage ($×1,000)			577.5	51.9	125.8	87.8			(7)				[9] 843.0
KENTUCKY:													
Number	0	0	1	0	0	0	0	0	0	0	0	0	1
Deaths			0										0
Injuries			2										2
Damage ($×1,000)			2.1										2.1
LOUISIANA:													
Number	0	1	1	1	0	0	0	1	0	0	3	0	7
Deaths		21	4	0				0			1		26
Injuries		40	9	8				0			10		67
Damage ($×1,000)		250.0	5.0	12.5				0.7			8.5		276.7
MINNESOTA:													
Number	0	0	0	0	0	0	2	1	0	0	1	0	4
Deaths							0	0			0		0
Injuries							2	15			1		18
Damage ($×1,000)							240.5	10.0			20.0		270.5
MISSISSIPPI:													
Number	0	0	1	4	0	0	0	0	0	0	1	0	6
Deaths			0	0							1		1
Injuries			0	16							0		16
Damage ($×1,000)			3.5	31.0							4.5		39.0
MISSOURI:													
Number	0	0	13	0	3	0	0	0	1	0	0	0	17
Deaths			16		0				0				16
Injuries			83		0				1				84
Damage ($×1,000)			[8] 491.7		13.5				(5)				[9] 505.2
NEBRASKA:													
Number	0	0	0	5	2	0	0	0	0	0	0	0	7
Deaths				3	0								3
Injuries				6	0								6
Damage ($×1,000)				40.0	50.0								90.0
OHIO:													
Number	0	0	0	0	0	1	0	0	0	0	0	0	1
Deaths						0							0
Injuries						0							0
Damage ($×1,000)						(3)							(3)
OKLAHOMA:													
Number	0	0	0	1	4	2	0	0	0	0	0	0	7
Deaths				0	0	0							0
Injuries				0	2	(1)							[9] 2
Damage ($×1,000)				10.0	6.1	85.0							101.1
PENNSYLVANIA:													
Number	0	0	0	0	1	1	0	0	0	0	0	0	2
Deaths					0	0							0
Injuries					0	0							0
Damage ($×1,000)					8.0	40.0							48.0
SOUTH CAROLINA:													
Number	0	0	0	0	4	0	0	0	5	0	0	0	9
Deaths					0				32				32
Injuries					0				150				150
Damage ($×1,000)					9.5				2,000.0				2,009.5
SOUTH DAKOTA:													
Number	0	0	0	0	0	2	2	2	1	0	1	0	8
Deaths						0	3	0	0		0		3
Injuries						1	16	0	0		0		17
Damage ($×1,000)						[2] 33.6	71.0	[8] 6.0	30.0		5.0		[9] 145.6
TEXAS:													
Number	0	1	5	1	5	2	0	1	0	0	1	0	16
Deaths		0	0	3	4	14		0			0		21
Injuries		24	0	50	10	10		0			2		96
Damage ($×1,000)		50.0	60.0	30.0	38.3	200.0		(7)			1.0		[9] 379.3
VIRGINIA:													
Number	0	0	0	0	2	1	0	0	0	0	0	1	4
Deaths					3	0						0	3
Injuries					2	0						0	2
Damage ($×1,000)					7.0	0.5						0.5	8.0
WISCONSIN:													
Number	0	0	0	0	1	0	1	1	0	0	0	0	3
Deaths					0		0	0					0
Injuries					2		0	0					2
Damage ($×1,000)					10.0		(7)	5.0					[9] 15.0
WYOMING:													
Number	0	0	0	0	0	1	0	0	0	0	0	0	1
Deaths						0							0
Injuries						0							0
Damage ($×1,000)						(3)							(3)
UNITED STATES:													
Number	0	2	60	26	42	21	13	8	8	0	8	1	189
Normal frequency	*3*	*4*	*16*	*23*	*31*	*26*	*18*	*7*	*8*	*3*	*5*	*3*	*141*
Deaths		21	74	17	15	14	3	0	32		2	0	178
Injuries		64	787	158	59	16	18	15	151		18	0	1,261
Damage ($×1,000)		300.0	3,627.8	305.7	659.0	447.9	358.1	21.7	2,030.0		39.5	0.5	7,790.2

[1] Several injured, definite figure not obtained.
[2] Additional losses of several thousand dollars, definite estimate not obtained.
[3] Small losses incurred.
[4] Losses incurred amounting to several hundred dollars, definite estimate not obtained.
[5] Losses incurred amounting to several thousand dollars, definite estimate not obtained.
[6] Losses incurred, less than one hundred dollars.
[7] Tornadoes (one or more) incurred no damage.
[8] Additional losses of several hundred dollars incurred, no definite estimate obtained.
[9] See references in monthly columns.

TABLE 2.—*Tornadic winds and possible tornadoes* [1]

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
ALABAMA:													
Number	1	0	0	0	0	0	0	0	0	0	0	0	1
Deaths	0												0
Injuries	0												0
Damage ($×1,000)	(2)												(2)
COLORADO:													
Number	0	0	0	0	0	0	0	1	0	0	0	0	1
Deaths								0					0
Injuries								0					0
Damage ($×1,000)								(2)					(2)
GEORGIA:													
Number	0	0	0	1	0	0	0	0	0	0	0	0	1
Deaths				0									0
Injuries				6									6
Damage ($×1,000)				(3)									(3)
INDIANA:													
Number	0	0	0	0	0	0	1	0	0	0	0	0	1
Deaths							3						3
Injuries							0						0
Damage ($×1,000)							50.0						50.0
IOWA:													
Number	0	0	1	0	0	0	0	0	0	0	0	0	1
Deaths			0										0
Injuries			0										0
Damage ($×1,000)			5.0										5.0
MICHIGAN:													
Number	0	0	0	0	0	0	0	2	0	0	0	0	2
Deaths								0					0
Injuries								7					7
Damage ($×1,000)								50.0					50.0
MINNESOTA:													
Number	0	0	0	0	0	0	0	1	0	0	0	0	1
Deaths								0					0
Injuries								2					2
Damage ($×1,000)								(3)					(3)
MISSISSIPPI:													
Number	0	0	0	0	1	0	0	0	0	0	0	0	1
Deaths					0								0
Injuries					25								25
Damages ($×1,000)					25.0								25.0
NEW JERSEY:													
Number	0	0	0	0	0	0	1	0	0	0	0	0	1
Deaths							0						0
Injuries							0						0
Damage ($×1,000)							25.0						25.0
PENNSYLVANIA:													
Number	0	0	0	0	0	0	1	0	0	0	0	0	1
Deaths							0						0
Injuries							0						0
Damage ($×1,000)							100.0						100.0
UNITED STATES:													
Number	1	0	1	1	1	0	3	4	0	0	0	0	11
Deaths	0		0	0	0		3	0					3
Injuries	0		0	6	25		0	9					40
Damage ($×1,000)	(3)		5.0	(3)	25.0		175.0	50.0					255.0

[1] These storms may or may not be classified as tornadoes when final study is made.
[2] Several hundred dollars.
[3] Several thousand dollars.

NORTH ATLANTIC TROPICAL DISTURBANCES OF 1938

By WILLIS E. HURD

[Weather Bureau, Washington, January 1939]

The hurricane season of 1938 in North Atlantic tropical waters lasted for 3 months, or from about the 10th of August until the 10th of November. Of the eight disturbances charted, one was of such slight intensity that it did not cause winds of gale force; two caused gales not exceeding 8 or 9 in force; one attained local force of 11 on 1 day; one attained hurricane force in local squalls on 1 day; and three may be classed as true hurricanes, among them one being of long sustained, terrific energy which resulted in a major disaster on September 21 to Long Island and a considerable part of New England, where in the neighborhood of 600 lives were lost and property to the value of at least a quarter billion dollars was destroyed. This was one of the few hurricanes of record to carry heavy destruction into the New England states.

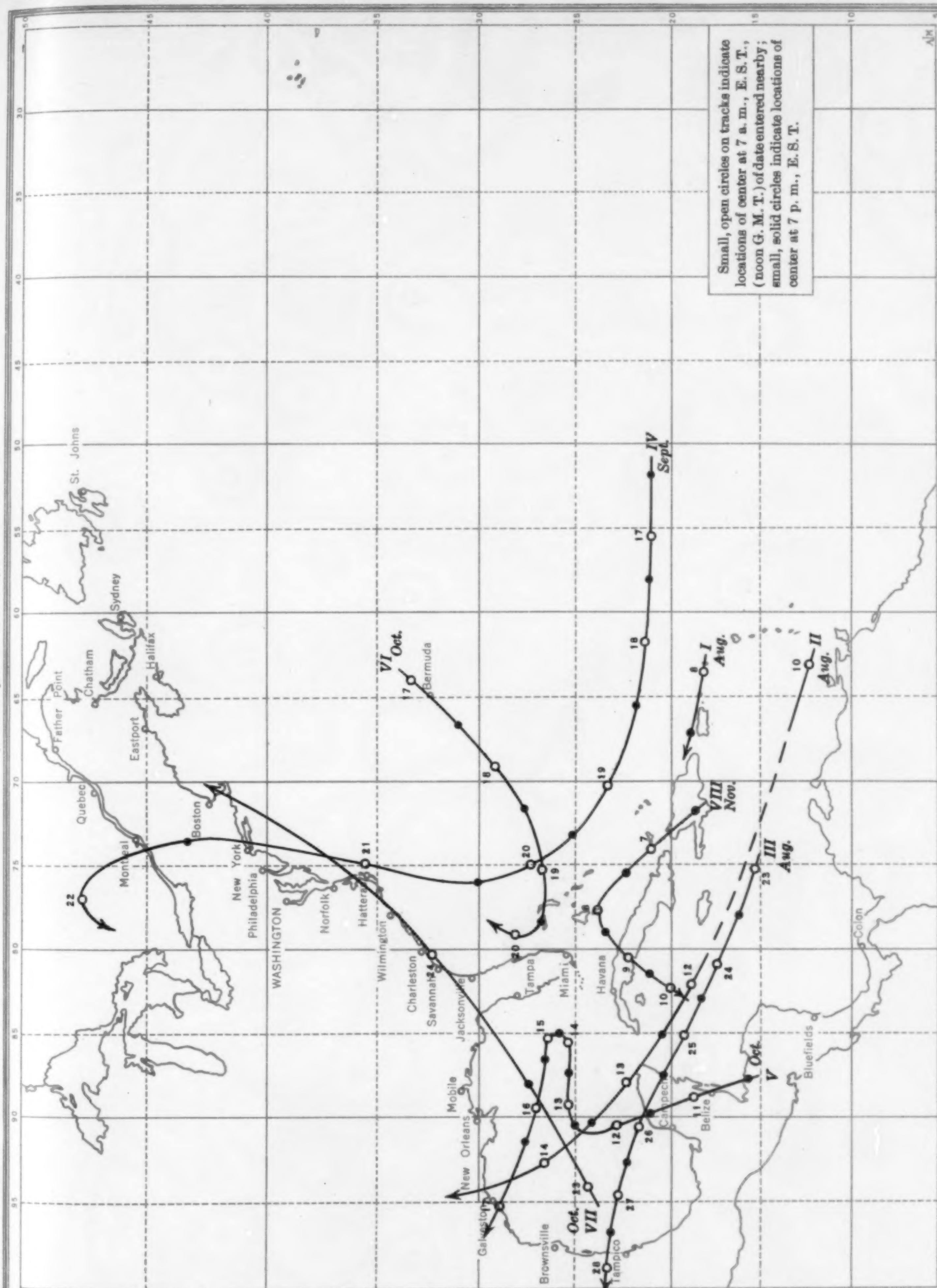
Five of the disturbances were shallow, in that their lowest reported central barometer readings did not fall to 29.50 inches; in two of the hurricanes the barometer fell below 29 inches, but in that of September central pressures were near or below 28 inches during most of its charted course.

Economically, exclusive of the New England hurricane, damage resulting from the 1938 disturbances was comparatively small, amounting perhaps to slightly more than a quarter million (estimated) dollars, of which the greatest part was done in southern Louisiana by the hurricane of August 9–14.

A synopsis of some of the more important features of the eight disturbances of 1938 is given in the table herewith. Their tracks, numbered I to VIII chronologically, are shown in the accompanying chart.

Four of the disturbances of the year crossed the Gulf of Mexico, and the entire eight were associated in all or some portions of their paths with the general West Indian region. Three were unusual in path. The track of the disturbance of October 10–17 (V) was very erratic in the Gulf of Mexico; that of October 17–21 (VI) originated in the extratropics near Bermuda and took a southwesterly course toward Florida; that of November 6–10 (VIII) took first a northwesterly then a southwesterly course into the Caribbean Sea.

Paths of Hurricanes and Other Tropical Storms of 1938
(Plotted by J. H. Gallenne)



North Atlantic tropical disturbances of 1938

[Synopsis of tropical disturbances of 1938 (number of storm in table corresponds to number of track on accompanying chart)]

Storm	Date	Place where first reported	Coast lines crossed	Maximum wind velocity reported	Lowest barometer reported	Place of dissipation	Intensity	Remarks
I	Aug. 8-10 [1]	East of Puerto Rico.	None	Force 12, E., S. S. *West Isleta*.	29.58, Tortola Island	Florida Straits	Squalls of hurricane intensity on the 8th.	Damage slight (A).
II	Aug. 9-14	Windward Islands	Louisiana	95 miles, E., Grand Cayman Island.	29.56, Lake Charles, La.	Western Louisiana.	Hurricane	About a quarter million damage, mostly in Louisiana (A).
III	Aug. 23-28	Central Caribbean Sea.	Mexico	Force 12, S., S. S. *Agwistar*; 90 miles M. S. *Sama*.	28.92, S. S. *Agwistar*	Mexico	Hurricane	Some damage due to wind and storm tide (A).
IV	Sept. 16-22 [2]	Near 21° N., 52° W.	Connecticut	Force 12, by several ships and land stations.	27.85, S. S. *Carinthia*	Canada	Intense hurricane.	Very damaging to New England. About 600 lives lost. Property damage $250,000,000 to $300,000,000 (B).
V	Oct. 10-17	Near Tela, Honduras.	Mexico, Texas	Force 9, NE., S. S. *El Isleo*.	29.41, S. S. *Wallace E. Pratt*.	Texas	Not of hurricane intensity.	No damage reported (C).
VI	Oct. 17-20	Near Bermuda	None	Force 6, 2 ships	29.78, near Florida coast.	North of Bahama Islands.	Slight	(C).
VII	Oct. 23-24	Near west-central Gulf of Mexico.	Florida; coast line of North Carolina and Massachusetts.	Force 8, NW., S. S. *Bertha Brovig*.	29.68, South Carolina coast before merging with northern LOW.	Merged with an extra-tropical LOW over New England.	Slight to moderate	(C).
VIII	Nov. 6-10 [3]	Haiti	Cuba	Force 11, N., S. S. *Marasi*.	29.54, Great Ragged Island, Bahamas.	Northwestern Caribbean.	Not of hurricane intensity.	Some damage due to wind and to wave erosion on the Florida east coast (D).

Complete reports of these disturbances may be found in the MONTHLY WEATHER REVIEW: (A) August 1938; 66: 240, 241. (B) September 1938; 66: 286, 288. (C) October 1938; 66: 325. (D) November 1938; 66: 378.

[1] Disturbance continued until the 10th, but there was no organized storm center except on the 8th.

[2] Some evidence of cyclonic circulation near 19° N., 37° W., on the 13th, but storm was not definitely charted until the 16th.

[3] Disturbed conditions occurred over the Leeward Islands as early as the 4th, but no organized storm center until the 6th.

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[RICHMOND T. ZOCH, *in Charge of Library*]

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SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

SOLAR RADIATION OBSERVATIONS, DECEMBER 1938

By IRVING F. HAND

Measurements of solar radiant energy received at the surface of the earth are made at eight stations maintained by the Weather Bureau, and at nine cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory of Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data, obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parenthesis). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 8 a. m. (75th meridian time) and at noon (local mean solar time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Direct radiation intensities averaged considerably above normal for December at Madison, slightly above normal at Lincoln and Blue Hill, and close to normal at Washington.

Total solar and sky radiation was above normal at all stations for which normals have been computed with the exception of Washington, Madison, New York, Fresno, La Jolla, and Blue Hill. For the year eight stations showed an excess of radiation and an equal number a deficiency; Chicago having the largest departure above normal and Washington the largest departure below normal. The algebraic sum of all the percentage departures from normal for continental United States is slightly positive; for all stations, including San Juan and Fairbanks, about 2 percent positive.

Polarization measurements made on 3 days at Madison give a mean of 57 percent with a maximum of 60 percent on the 21st. Both of these values are slightly below the corresponding normals for the month; due partly, at least, to partial snow cover.

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TABLE 1.—*Solar radiation intensities during December 1939*

[Gram-calories per minute per square centimeter of normal surface]

Date		Sun's zenith distance									
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
WASHINGTON, D. C.											
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Dec. 1	4.17							0.74			3.00
Dec. 6	4.57	0.73	0.91	1.01	1.24			.97			3.81
Dec. 7	3.81	.71	.93	1.04	1.24						3.99
Dec. 13	2.49				1.22						2.26
Dec. 14	2.87		1.11	1.21							3.15
Dec. 15	2.06			.83	1.23			1.13	0.95	0.78	1.96
Dec. 16	1.88	.70	.90	1.04	1.17						2.62
Dec. 19	3.30	.81	.90	.98	1.07						2.74
Dec. 20	2.62				1.05						2.62
Dec. 22	2.87	.83	1.04	1.10	1.24						2.87
Dec. 28	1.07	.83	.97	1.14	1.31						.91
Means		.77	.97	1.04	1.20			1.08	.95	.78	
Departures		−.01	+.06	−.01	−.03			−.09	+.04	−.01	
MADISON, WIS.											
Dec. 13	1.96	1.07	1.12	1.26							2.62
Dec. 14	1.78	1.20	1.29	1.40							1.12
Dec. 21	2.62	1.10	1.20	1.32							2.36
Dec. 27	.74			1.30							.91
Means		1.12	1.20	1.32							
Departures		+.15	+.11	+.10							
LINCOLN, NEBR.											
Dec. 1	3.63								0.84	0.67	4.37
Dec. 3	3.15			1.20							2.74
Dec. 5	3.30								.97	.92	3.81
Dec. 6	4.17								1.15		3.63
Dec. 12	1.68				1.49				1.17	1.08	1.45
Dec. 13	1.60	1.06	1.12	1.28	1.52			1.31	1.13	.96	2.06
Dec. 17	1.88	.85	.89	1.29							1.93
Dec. 21	1.78	1.07	1.21	1.33	1.44						2.74
Dec. 28	1.19	.82									1.78
Dec. 29	.91	1.02	1.15	1.29	1.48						1.02
Dec. 30	1.07	.94	1.05	1.22							1.24
Means		.99	1.11	1.28	1.49			1.31	1.05	.91	
Departures		+.03	+.01	+.04	+.09			+.11	−.02	−.05	
BLUE HILL, MASS.											
Dec. 1	2.1	0.75	0.85	0.97	1.01		0.89	0.85			2.1
Dec. 2	1.0						1.33	1.27			1.0
Dec. 13	2.2	1.01	1.11	1.23	1.31		1.33	1.18			2.2
Dec. 14	2.2				1.39						2.6
Dec. 15	1.2				1.38		1.35				1.6
Dec. 22	2.2			1.15	1.25		1.17	.94			1.9
Dec. 23	1.2			1.29	1.28		1.20				1.3
Dec. 25	3.0			1.20	1.32		1.32	1.00			3.0
Dec. 26	1.3			1.20	1.30						1.8
Dec. 27	5.3			1.20	1.40		1.30	1.00			8.9
Means		(.88)	(.98)	1.18	1.29		1.24	1.04			
Departures		.00	−.07	.00	−.07		−.04	−.09			

[1] Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Gram-calories per square centimeter																
	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca	Newport
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Dec. 3	119	47	179	48	90	95	11	115	281	333	280	247	96	460	66	76	116
Dec. 10	171	149	175	130	110	111	6	162	175	277	236	193	142	441	129	255	178
Dec. 17	124	113	192	68	170	168	4	104	205	341	190	177	91	412	70	31	96
Dec. 24 [1]	178	135	212	87	121	158	12	120	258	319	161	251	166	415	51	80	162
	Departures of daily totals from normals																
Dec. 3	−38	−67	+5	−21	−13	−88	+3	0	+36	+26	+81	+35	−33	+22	−18	−20	-------
Dec. 10	+52	+36	+10	+49	+6	−50	0	+44	−52	−25	+6	−3	+9	+7	+48	+155	-------
Dec. 17	−20	−6	+15	−17	−27	+25	−2	−13	−37	+58	−29	−60	−40	−2	−1	−59	-------
Dec. 24	+7	+13	+36	+3	+7	+24	+5	−12	+39	+34	+8	+43	+29	+35	−7	−7	-------
	Accumulated departures since Jan. 1, 1938																
	−11,368	−756	+2,772	+11,592	+4,928	−3,451	+4,739	−9,063	−1,330	−4,440	+10,395	−5,761	−3,180	+13,606	+6,986	+2,219	-------
	Percentage departures for the year																
	−9.4	−0.6	+2.0	+11.6	+4.7	−2.0	+5.9	−6.4	−0.8	−2.9	+7.4	−3.8	−2.6	+7.6	+6.0	+2.0	-------

[1] Eight-day period.

LATE DATA

The values of total solar and sky radiation, expressed in gram calories, received on a horizontal surface at Miami, Fla., for the weeks beginning October 29, November 5, 12, 19, and 29, are 366, 316, 355, 309, and 328, respectively, with corresponding departures of +36, −29, +13, −14, and +43.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time		Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
				Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
1938	*h*	*m*		°	°	°				
Dec. 1	11	26	6221	−82.0	274.5	−10.0	679	-------	3	U. S. Naval.
			6220	−73.0	283.5	+12.0	48	-------	2	
			6219	−37.0	319.5	+12.0	133	-------	5	
			6213	+39.0	35.5	+14.0	1,697	-------	90	
			6214	+39.0	35.5	−18.0	582	3,139	24	
Dec. 2	11	42	6221	−70.0	273.1	−10.0	679	-------	5	Mt. Wilson.
			6220	−58.0	285.1	+12.0	48	-------	1	
			6219	−20.0	323.1	+12.0	73	-------	10	
			6222	−15.0	328.1	+17.0	48	-------	1	
			6214	+52.0	35.1	−17.0	727	-------	40	
			6213	+52.0	35.1	+14.0	1,697	3,272	90	
Dec. 3	11	14	6223	−63.0	267.2	+23.0	36	-------	1	U. S. Naval.
			6221	−58.0	272.2	−10.0	776	-------	7	
			6224	−45.0	285.2	−10.5	24	-------	2	
			6220	−44.0	286.2	+11.5	24	-------	1	
			6219	−7.0	323.2	+10.5	97	-------	7	
			6213	+65.0	35.2	+14.0	1,357	-------	45	
			6214	+66.0	36.2	−18.0	582	2,896	10	
Dec. 4	1	3	6225	−75.0	242.1	−8.0	194	-------	4	Mt. Wilson.
			6223	−49.5	267.6	+23.0	24	-------	2	
			6221	−42.0	275.1	−10.0	921	-------	8	
			6224	−31.0	286.1	−10.0	24	-------	3	
			6219	+6.0	323.1	+12.0	97	-------	10	
			6213	+72.0	29.1	+15.0	1,164	-------	18	
			6214	+82.0	39.1	−18.0	291	2,715	8	
Dec. 5	17	4	6225	−57.0	243.6	−7.0	291	-------	20	Do.
			6223	−33.0	267.6	+23.0	24	-------	2	
			6227	−29.0	271.6	−4.0	48	-------	5	
			6221	−27.0	273.6	−10.0	727	-------	12	
			6224	−17.0	283.6	−9.5	48	-------	12	
			6220	−16.0	284.6	+11.0	48	-------	3	
			6219	+21.0	321.6	+11.0	97	1,283	8	
Dec. 6	11	21	6233	−78.0	212.6	−21.5	194	-------	4	U. S. Naval.
			6229	−68.0	222.6	+24.0	24	-------	2	
			6225	−46.0	244.6	−7.0	291	-------	11	
			6223	−25.0	265.6	+22.0	24	-------	5	
			6227	−19.5	271.1	−5.0	24	-------	3	
			6221	−17.0	273.6	−11.0	776	-------	10	
			6226	−7.0	283.6	−3.0	12	-------	1	
			6224	−5.0	285.6	−9.5	194	-------	10	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time		Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
				Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
1938	*h*	*m*		°	°	°				
Dec. 6	11	21	6219	+34.0	324.6	+10.5	61	-------	5	U. S. Naval.
			6230	+36.0	326.6	+23.0	85	-------	5	
			6231	+36.0	326.6	−17.0	24	1,709	3	
Dec. 7	10	52	6233	−80.0	197.7	−18.0	291	-------	2	Do.
			6233	−70.0	207.7	−21.0	194	-------	16	
			6234	−47.0	230.7	−7.0	24	-------	1	
			6225	−34.0	243.7	−7.0	194	-------	12	
			6227	−6.0	271.7	−5.0	24	-------	3	
			6221	−3.0	274.7	−10.5	727	-------	8	
			6224	+8.5	286.2	−9.5	291	-------	9	
			6219	+46.0	323.7	+10.5	24	-------	2	
			6230	+49.5	327.2	+23.0	61	-------	2	
			6231	+50.0	327.7	−17.0	24	1,854	1	
Dec. 8	10	58	6233	−68.0	196.5	−18.5	291	-------	4	Do.
			6233	−57.0	207.5	−21.0	436	-------	31	
			6233	−45.0	219.5	−17.0	12	-------	2	
			6234	−30.0	234.5	−6.0	194	-------	15	
			6225	−20.0	244.5	−7.0	242	-------	19	
			6228	−13.0	251.5	−12.0	24	-------	4	
			6221	+10.0	274.5	−11.0	630	-------	20	
			6220	+21.5	286.0	+10.5	12	-------	3	
			6224	+22.0	286.5	−9.0	291	-------	29	
			6235	+48.0	312.5	−7.0	6	-------	1	
			6230	+60.0	324.5	+24.0	12	-------	3	
			6219	+60.0	324.5	+10.5	6	-------	3	
			6231	+65.0	329.5	−16.0	6	2,162	1	
Dec. 10	10	52	6239	−66.0	172.2	−9.0	242	-------	1	Do.
			6233	−41.0	197.2	−19.0	242	-------	2	
			6238	−33.0	205.2	+6.5	218	-------	10	
			6243	−30.0	208.2	−21.0	145	-------	9	
			6233	−19.0	219.2	−16.0	12	-------	2	
			6234	−3.0	235.2	−5.0	194	-------	10	
			6225	+7.0	245.2	−6.0	242	-------	20	
			6221	+36.0	274.2	−10.5	388	-------	8	
			6224	+49.5	287.7	−9.0	218	1,901	2	
Dec. 12	14	14	6241	−45.0	165.0	+9.0	48	-------	3	Do.
			6240	−37.0	173.0	+10.5	24	-------	2	
			6239	−37.0	173.0	−9.5	242	-------	2	
			6242	−2[illegible].0	183.0	−10.0	48	-------	5	
			6243	−14.0	196.0	−19.0	194	-------	9	
			6233	−7.0	203.0	−20.0	291	-------	28	
			6238	−4.0	206.0	+6.0	291	-------	11	
			6233	+5.0	215.0	−20.0	36	-------	2	
			6234	+28.0	238.0	−6.0	145	-------	1	
			6225	+34.0	244.0	−6.0	242	-------	15	
			6232	+60.0	270.0	−20.0	121	-------	4	
			6221	+65.0	275.0	−10.5	364	-------	7	
			6224	+78.0	288.0	−8.0	48	2,094	3	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mt. Wilson group No.	Heliographic			Area		Spot count	Observatory
			Diff. in longitude	Longitude	Latitude	Spot or group	Total for each day		
1938	h m		°	°	°				
Dec. 13	10 59	6244	−79.0	119.6	+27.0	242	-------	1	U. S. Naval.
		6241	−34.0	164.6	+10.0	6	-------	1	
		6240	−26.0	172.6	+11.5	6	-------	1	
		6243	−25.0	173.6	+6.0	6	-------	3	
		6239	−25.0	173.6	−9.5	206	-------	1	
		6242	−13.0	185.6	−9.5	24	-------	2	
		6233	+1.0	199.6	−19.5	339	-------	31	
		6238	+8.0	206.6	+5.0	255	-------	20	
		6233	+18.0	216.6	−19.5	73	-------	6	
		6234	+41.0	239.6	−6.0	61	-------	1	
		6225	+48.0	246.6	−7.0	291	-------	10	
		6232	+70.0	268.6	−20.5	121	-------	1	
		6221	+76.0	274.6	−11.5	339	1,969	5	
Dec. 14	12 7	6247	−78.0	106.8	−8.0	97	-------	2	Do.
		6244	−64.0	120.8	+26.0	291	-------	2	
		6239	−11.0	173.8	−10.0	218	-------	1	
		6242	+2.0	186.8	−9.0	121	-------	10	
		6233	+12.0	196.8	−19.0	121	-------	15	
		6233	+18.0	202.8	−22.0	97	-------	5	
		6233	+20.0	204.8	−18.0	73	-------	10	
		6238	+21.0	205.8	+6.0	218	-------	15	
		6233	+31.0	215.8	−19.0	48	-------	6	
		6234	+59.0	243.8	−5.0	291	1,575	6	
Dec. 15	11 7	6247	−64.0	108.1	−6.0	97	-------	7	Do.
		6244	−50.0	122.1	+27.0	242	-------	2	
		6239	+1.0	173.1	−10.0	218	-------	2	
		6242	+17.0	189.1	−10.0	145	-------	10	
		6233	+22.0	194.1	−19.0	145	-------	15	
		6233	+29.0	201.1	−22.0	48	-------	2	
		6238	+39.0	211.1	+5.0	170	-------	20	
		6233	+44.0	216.1	−20.0	36	-------	2	
		6234	+70.0	242.1	−7.0	145	1,246	4	
Dec. 16	11 45	6247	−52.0	106.6	−5.0	267	-------	25	Do.
		6246	−40.0	118.6	+13.0	48	-------	3	
		6244	−38.0	120.6	+27.0	364	-------	3	
		6241	+3.0	161.6	+7.0	6	-------	1	
		6240	+11.0	169.6	+13.0	12	-------	1	
		6239	+15.0	173.6	−9.0	194	-------	1	
		6243	+16.0	174.6	+5.0	12	-------	3	
		6242	+29.0	187.6	−9.0	97	-------	18	
		6233	+36.0	194.6	−19.0	97	-------	12	
		6233	+40.5	199.1	−22.5	24	-------	6	
		6238	+46.0	204.6	+5.0	73	-------	13	
		6238	+55.0	213.6	+5.0	97	-------	12	
		6245	+69.0	227.6	−12.0	12	-------	2	
		6234	+83.0	241.6	−6.0	194	1,497	2	
Dec. 19	11 46	6252	−84.0	35.1	+15.0	194	-------	3	Do.
		6251	−81.0	38.1	−16.0	339	-------	2	
		(*)	−33.0	86.1	+8.0	24	-------	6	
		6247	−12.0	107.1	−5.0	436	-------	75	
		6244	0.0	119.1	+28.0	315	-------	17	
		6239	+54.0	173.1	−9.5	206	-------	1	
		(*)	+59.0	178.1	+14.0	61	-------	9	
		6242	+69.0	188.1	−9.0	121	-------	12	
		(*)	+70.5	189.6	+10.5	61	1,757	6	
Dec. 20	10 58	6252	−70.0	36.4	+15.0	436	-------	14	Do.
		6251	−67.0	39.4	−16.0	533	-------	9	
		6247	+1.0	107.4	−5.0	485	-------	83	
		6244	+7.0	113.4	+29.0	24	-------	11	
		6244	+12.5	118.9	+28.0	315	-------	7	
		6239	+68.0	174.4	−9.5	206	-------	1	
		(*)	+68.0	174.4	−18.0	12	-------	5	
		(*)	+73.0	179.4	+15.0	145	2,156	6	
Dec. 21	10 57	6252	−58.0	35.2	+16.0	436	-------	33	Do.
		6251	−51.0	42.2	−17.0	533	-------	18	
		(*)	−29.0	64.2	−10.5	24	-------	3	
		6247	+15.0	108.2	−4.0	582	-------	80	
		6244	+25.0	118.2	+28.0	242	-------	5	
		6239	+80.0	173.2	−9.5	194	2,011	2	
Dec. 22	11 10	6252	−45.0	34.9	+16.0	582	-------	45	Do.
		6251	−38.0	41.9	−17.0	533	-------	20	
		6247	+30.0	109.9	−4.0	679	-------	62	
		(*)	+32.0	111.9	+12.0	24	-------	2	
		6244	+39.0	118.9	+28.0	315	-------	5	
		(*)	+51.0	130.9	+15.0	61	2,194	8	
Dec. 23	12 5	6252	−32.0	34.2	+15.0	436	-------	(1)	Mt. Wilson.
		6251	−27.0	39.2	−18.0	388	-------	-------	
		6250	−21.0	45.2	−19.0	48	-------	-------	
		6247	+44.0	110.2	−4.0	388	-------	-------	
		6244	+54.0	120.2	+27.0	145	1,405	-------	
Dec. 24	12 6	6254	−73.0	340.1	−2.0	97	-------	3	Do.
		6252	−18.0	35.1	+15.0	582	-------	22	
		6251	−15.0	38.1	−18.0	533	-------	2	
		6250	−7.0	46.1	−17.0	24	-------	2	
		6253	+17.5	70.6	+17.0	24	-------	1	
		6247	+58.0	111.1	−4.0	388	-------	9	
		6244	+68.0	121.1	+27.0	194	1,842	3	
Dec. 25	13 55	6254	−58.0	340.9	−1.5	194	-------	5	U. S. Naval.
		6252	−4.0	34.9	+15.0	679	-------	55	
		6251	0.0	38.9	−18.0	388	-------	1	
		6250	+8.5	47.4	−17.0	12	-------	3	
		6255	+10.0	48.9	+13.0	12	-------	3	
		6247	+72.0	110.9	−4.0	388	-------	15	
		6244	+81.0	119.9	+28.0	194	1,867	3	
Dec. 26	12 18	6254	−46.0	340.6	−1.5	145	-------	8	Mt. Wilson.
		6252	+7.0	33.6	+14.0	582	-------	120	
		6151	+11.0	37.6	−19.0	388	-------	8	
		6255	+21.0	47.6	+12.0	48	-------	10	
		6253	+37.5	64.1	+17.0	194	-------	24	
		6247	+85.0	111.6	−4.0	67	1,454	4	
Dec. 27	10 49	6254	−33.0	341.2	−1.5	121	-------	1	U. S. Naval.
		6252	+20.0	34.2	+14.0	485	-------	2	
		6251	+24.0	38.2	−19.0	339	-------	28	
		6253	+50.0	64.2	+17.0	145	1,090	9	
Dec. 28	12 11	6254	−19.0	341.3	−1.5	145	-------	1	Do.
		6252	+34.0	34.3	+14.0	388	-------	21	
		6251	+38.0	38.3	−19.0	291	-------	1	
		6255	+41.0	41.3	+11.0	48	-------	4	
		6253	+66.0	66.3	+18.0	73	945	1	
Dec. 29	12 14	6258	−80.0	267.1	−12.0	291	-------	6	Do.
		6254	−5.0	342.1	−1.5	97	-------	3	
		6252	+48.0	35.1	+13.0	291	-------	11	
		6251	+50.0	37.1	−19.5	242	921	1	
Dec. 30	11 18	6260	−80.0	254.5	−10.0	73	-------	1	Do.
		6258	−68.0	266.5	−12.0	485	-------	7	
		6254	+7.0	341.5	−1.5	145	-------	5	
		6252	+60.0	34.5	+13.0	291	-------	15	
		6251	+63.0	37.5	−19.0	436	-------	1	
		6255	+68.0	42.5	+10.5	24	1,454	2	
Dec. 31	10 41	6259	−80.0	241.1	−18.0	145	-------	2	Do.
		6260	−66.0	255.1	−11.0	48	-------	2	
		6258	−54.0	267.1	−12.0	436	-------	5	
		6254	+19.0	340.1	−1.5	145	-------	5	
		6252	+72.0	33.1	+13.0	242	-------	8	
		6251	+78.0	39.1	−19.0	291	1,307	5	

Mean daily area for 27 days=1,841.

*Not numbered.
[1] Poor plate.

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR DECEMBER 1938

[Dependent alone on observations at Zurich, Switzerland]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Starnwarte, Zurich, Switzerland]

December 1938	Relative numbers	December 1938	Relative numbers	December 1938	Relative numbers
1	*d* 97	11	*Wc* 129	21	--------
2	82	12	*Eaac* 154	22	88
3	*Ec* 64	13	*aad* 124	23	--------
4	*ad* 82	14	*a* 151	24	*d* 88
5	58	15	*a* ---	25	--------
6	*d* 90	16	----------	26	*ab* 73
7	*Eaac* 117	17	----------	27	--------
8	106	18	*add* ---	28	--------
9	*Ecd* 130	19	*a* ---	29	*d* 64
10	*aa* ---	20	----------	30	*a* 44
				31	*d* 63

Mean, 19 days=94.9.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE in charge]

By B. FRANCIS DASHIELL

In December a total of 497 airplane and radiosonde upper-air observations were made in the United States. The mean free-air data based on these observations are shown in tables 1 and 1a, and include pressure (P), temperature (° C.), and relative humidity (R. H.), recorded at certain standard geometric heights. During the month 78 radiosonde observations were taken at 17 kilometers over the six stations listed in table 1a. This represented 42 percent of all observations launched at the surface. The "means" are omitted from the tables whenever less than 15 observations are made at the surface and less than 5 at a standard height, but 15 observations are necessary for those levels that fall within the limits of the monthly vertical range of the tropopause.

Chart I shows the departure of mean *surface* temperatures (° F.) from normal. The weather over most of the United States was warmer than normal, and decidedly above in the regions west of the Mississippi River valley. Over the northern Rocky Mountain region the mean temperatures were as much as 7° F. above their normals for December. Temperatures also were moderately high, ranging from 2° F. to 4° F. over New England and portions of the lower Lakes region. But departures from the mean temperature were very slight over the Southeast, being 1° F. to 2° F. below normal in the east Gulf States. Temperatures along the north Pacific coast were about normal in December.

Mean free-air temperatures (° C.), recorded *above* the surface, are given in tables 1 and 1a. During December the lowest mean temperatures at the surface and 0.5 kilometer, respectively (−10.2° C. and −8.6° C.), were recorded over Fargo, N. Dak. But at all other levels, up to and including 7 kilometers, the lowest mean temperatures (−8.7° C., −10.6° C., −12.1° C., −13.7° C., −15.4° C., −20.7° C., −26.8° C., −32.7° C., and −39.8° C., respectively), occurred over Sault Ste. Marie, Mich. At 8, 9, and 10 kilometers, however, Fargo, N. Dak., again became the coldest station (−47.1° C., −52.8° C., and −54.9° C., respectively). The lowest temperatures at 11 and 12 kilometers were found over Omaha, Nebr. (−55.4° C.), and Oakland, Calif. (−57.1° C.), respectively. Above 12 kilometers the lowest temperatures were reported over Oklahoma City, Okla., being −56.6° C., −59.0° C., −61.3° C., −63.6° C., −67.2° C., and −68.4° C., respectively, at 12, 13, 14, 15, 16, and 17 kilometers. However, in these same levels—from 12 to 17 kilometers, inclusive—higher temperatures than elsewhere were recorded over Fargo, N. Dak., and Sault Ste. Marie, Mich. At Omaha, Nebr., where a maximum altitude of 20 kilometers was reached by radiosonde, a slight increase in mean temperature (−63.8° C., −63.5° C., −62.9° C., and −62.2° C., respectively) was noted at 17, 18, 19, and 20 kilometers.

December was seasonally colder than the preceding month of November at nearly all stations. But exceptions occurred at Oakland, Calif., San Diego, Calif., and El Paso, Tex., where the December means were slightly higher than in November at the lower levels, while at Salt Lake City, Utah, and Billings, Mont., temperatures were somewhat higher at all levels. Spokane, Wash., was warmer than November only at 2, 2.5, and 3 kilometers. The highest mean temperatures for December occurred over Oakland, Calif., in the lower levels up to 2.5 kilometers. But above that level, up to 5 kilometers, inclusive, the highest temperatures were recorded over Pensacola, Fla. Mean free-air temperatures for the country as a whole were very slightly higher than those noted during the other winter months of January and February 1938, while over the South they were actually lower at all levels above 2.5 kilometers.

During December the mean atmospheric pressures over the United States were well distributed in the upper air, and definitely located a statistical low-pressure center over Sault Ste. Marie, Mich., at all levels. Pressure was highest over the southern States, and extended from Pensacola, Fla., to the Pacific coast (San Diego, Calif.) and thence northward to Oakland, Calif. The mean pressures over Pensacola, Fla., slightly exceeded those recorded elsewhere in this belt of high pressure. At each level the differences between the low pressure area located over Sault Ste. Marie, Mich., and the high pressures centered over Pensacola, Fla., were found to increase steadily with altitude. For example, these differences in millibars, were: 12, 15, 17, 20, 21, 23, 25, and 26, at 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. December mean pressures were found to be slightly lower than those for November at most stations. Also, the mean low pressures that were recorded in December at 0.5, 1, 4, and 5 kilometers were less than those noted in any month of the year and second only to the lowest means for the year which were recorded in January 1938 at 1.5, 2, 2.5, and 3 kilometers.

The mean relative humidity for December was somewhat higher generally than during the previous month. This situation was observed over the entire country at all levels, except in the South over Pensacola, Fla., and over the northern Rocky Mountain region at Billings, Mont. The highest humidity at all levels occurred over Sault Ste. Marie, Mich., where barometric pressures and mean temperatures were lowest. Relative humidity ranged from a mean of 91 percent at 0.5 kilometer to 69 percent at 5 kilometers, and 65 percent at 7 kilometers over Sault Ste. Marie, Mich. Since the temperature at 7 kilometers fell below −40.0° C. no additional humidity data are available. The lowest mean humidities prevailed over El Paso, Tex., at the surface and 1.5 kilometers, and then over Pensacola, Fla., at all other levels, becoming 15 percent at 5 kilometers. A tendency toward high humidity was noted over the central Rocky Mountain region, particularly at Salt Lake City, Utah, for all levels.

Table 2 shows free-air resultant wind directions and velocities based on pilot-balloon observations made near 5 a. m. (75th meridian time) during December. Resultant wind directions were nearly normal over all stations making such observations, with the exception of those on the Pacific coast and, to a much lesser extent, in the Southeast. The current resultant wind directions at San Diego, Calif., and Medford, Oreg., showed abnormal departures at all levels. Resultant wind velocities remained about normal at many stations, but a few showed considerable variation. Velocity departures, as a rule, were positive, or greater than normal, while directional departures were about equally divided between orientations that were clockwise and counterclockwise with respect to normal.

Departures of current resultant wind directions from their normal at the surface were remarkably small. Surface variations, as a rule, are rather large, but during December the average of all surface departures was less

than in any other month of 1938. The outstanding exception to this situation existed at Sault Ste. Marie, Mich., where the difference of 105° was oriented counterclockwise with respect to the normal direction. Above the surface, the greatest average departure of any level was 24° at 1.5 kilometers, and the least was 10° at 5 kilometers. But, disregarding the abnormal directions on the Pacific coast, the average departure for each level in December was more uniform—about 10°.

Resultant winds during December were unusual along the Pacific coast. The two outstanding stations for the month, San Diego, Calif., and Medford, Oreg., showed the largest departures recorded at any station during 1938. A midway point, Oakland, Calif., was the third outstanding station during December. But farther north, at Seattle, Wash., directional departures were slight, being less than in any month of the year except January and April 1938. The only other pilot-balloon stations showing departures in direction worthy of note were Key West, Fla., and Pensacola, Fla. The directions at Pensacola, Fla., however, held closer to the normal resultant in December than during any month of 1938, while a similar condition existed at Key West, Fla., except for the months of May, June, and August 1938.

The December resultant wind directions at San Diego, Calif., were: 20°, 119°, 69°, 167°, 96°, 42°, 23°, 360°, and 323° as compared with the normal directions of 49°, 13°, 352°, 328°, 328°, 315°, 319°, and 311° at the surface, and 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. Slightly smaller variations occurred at Medford, Oreg., and there the directions were: 98°, 31°, 135°, 154°, 166°, 174°, 168°, and 98°, as compared to the normals of 143°, 144°, 163°, 212°, 228°, 237°, 253°, and 261° at the surface, and 0.5, 1, 1.5, 2, 2.5, 3, and 4 kilometers, respectively. At Oakland, Calif., the December directions were: 73°, 47°, 39°, 33°, 25°, 344°, 333°, and 310°, as compared to the normals of 94°, 47°, 15°, 320°, 320°, 313°, 308°, and 284° at the surface, and 0.5, 1, 1.5, 2, 2.5, 3, and 4 kilometers, respectively.

Wind directions at all levels were nearly normal at Brooklyn, N. Y., Cheyenne, Wyo., Albuquerque, N. Mex., Billings, Mont., Fargo, N. Dak., Atlanta, Ga., Chicago, Ill., Cincinnati, Ohio, Nashville, Tenn., and St. Louis, Mo. At Spokane, Wash., and Oklahoma City, Okla., the wind directions were oriented in a clockwise rotation from normal at all levels; and at San Diego and Oakland, Calif., Billings, Mont., and Cheyenne, Wyo., for all levels except the surface. Medford, Oreg., Sault Ste. Marie, Mich., Chicago, Ill., and Cincinnati, Ohio, reported current winds that departed counterclockwise from normal at all levels.

The wind directions for December showed that westerly components prevailed at all stations for all levels above 2 kilometers, except at San Diego, Calif., and Medford, Oreg. Westerly resultant directions occurred in 71 percent of the observations at the surface, 73 percent at 0.5 kilometer, 80 percent at 1 kilometer, 83 percent at 1.5 kilometers, and 100 percent at 2, 2.5, 3, 4, and 5 kilometers, inclusive. Most of the westerly winds fell within the northwest quadrant, and this condition became more pronounced with altitude, for, at 2 kilometers, 70 percent of the resultants had northwest components, 85 percent at 2.5 kilometers, 91 percent at 3 kilometers, 94 percent at 4 kilometers, and 100 percent at 5 kilometers.

Resultant wind velocities for December were not as high, on the whole, as in the preceding month of November. Departures from normal velocities were mostly negative, or less than normal, at San Diego, Calif., and Medford, Oreg., where large and unusual departures in direction have been noted. At Medford, Oreg., the velocities were less than normal by 0.1, 0.5, 1.0, 0.8, 0.9, 1.2, and 0.1 meters per second, at the surface, and 0.5, 1, 2, 2.5, 3, and 4 kilometers, respectively, and greater than normal by 0.8 meters per second at 1.5 kilometers. At San Diego, Calif., the velocities also were less than normal by 0.8, 0.6, 1.3, 1.6, 1.9, 1.4, and 0.4 meters per second at the surface, and 1.5, 2, 2.5, 3, 4, and 5 kilometers, and greater than normal by 0.4 and 0.2 meters per second at 0.5 and 1 kilometers, respectively. The December velocities at Oakland, Calif., were greater than normal at all levels by small amounts. In connection with the abnormal conditions that prevailed on the Pacific coast in December it should be noted that the normal resultant velocities for the month are lower in that section than elsewhere over the United States, except at Key West and Pensacola, Fla.

Resultant wind velocities that were nearly normal occurred at Houston, Texas, St. Louis, Mo., Cincinnati, Ohio, Atlanta, Ga., and Boston, Mass. Directional departures at these places also were insignificant. But, at Sault Ste. Marie, Mich., Seattle, Wash., Oklahoma City, Okla., and Billings, Mont., the December average velocity departures were largest for the country. High positive velocity departures were recorded in the 4- and 5-kilometer levels over Cheyenne, Wyo., Nashville, Tenn. (+4.5 m. p. s. at 4 kilometers), Omaha, Nebr., and Oklahoma City, Okla., and the largest negative departures occurred over Spokane, Wash., and Seattle, Wash. (−4.3 m. p. s.), at 4 kilometers.

Table 3 shows the maximum wind velocities recorded over the country during December. As in November, high velocities in the upper air were noted, but none that were so excessive. However, no velocities recorded between the surface and 2.5 kilometers equalled those reported during the previous months of 1938, but between 2.5 and 5 kilometers the velocities of 47.5 and 50 meters per second, respectively, at Charleston, S. C., and Springfield, Ill., were the highest recorded in those sections during 1938. Above 5 kilometers the velocities of 53.2, 76.8, and 68.0 meters per second, respectively, at Nashville, Tenn., Wichita, Kans., and Oklahoma City, Okla., were the highest reported from those sections in 1938. And the highest velocity reported in December, 78.8 meters per second from the North at 10 kilometers elevation of the 7th at Albuquerque, N. Mex., is a record wind speed at that place.

TABLE 1.—*Mean free-air barometric pressures (P) in mb., temperatures (T) in °C., and relative humidities (R. H.) in percent obtained by airplanes during December 1938*

Altitude (meters) m. s. l.

Stations and elevations in meters above sea level	Surface: Number of obs.	Surface: P	Surface: T	Surface: R H	500: P	500: T	500: R H	1,000: P	1,000: T	1,000: R H	1,500: P	1,500: T	1,500: R H
Billings, Mont. (1090 m)	31	891	−2.5	59							846	−0.1	53
Cheyenne, Wyo. (1873 m)	30	810	−4.4	68									
Chicago, Ill. (187 m)	31	995	−3.6	82	956	−3.8	81	898	−4.5	73	842	−4.7	62
Coco Solo, C. Z.[1] (15 m)	22	1010	25.0	85	956	23.0	82	903	20.2	83	852	17.4	78
El Paso, Tex. (1193 m)	31	884	3.7	50							852	8.9	42
Lakehurst, N. J.[1] (39 m)	26	1014	−0.9	84	957	−0.3	72	899	−2.9	66	844	−3.3	62
Norfolk, Va.[1] (10 m)	16	1023	3.2	85	963	3.6	80	905	2.1	71	850	.8	65
Pearl Harbor, T. H.[1] (6 m)	31	1016	21.5	79	960	21.0	76	906	17.8	80	854	15.6	77
Pensacola, Fla.[1] (13 m)	23	1022	5.8	90	964	10.3	61	908	8.8	60	854	7.6	53
St. Thomas, V. I.[1] (8 m)	31	1015	25.5	80	960	22.4	87	906	19.6	84	855	16.6	82
Salt Lake City, Utah (1288 m)	31	876	−0.9	87							853	1.1	73
San Diego, Calif.[1] (10 m)	31	1017	10.7	86	959	14.0	75	904	12.7	65	851	10.0	61
Spokane, Wash. (597 m)	31	949	−.5	87				903	−.8	81	848	−1.8	73

Stations and elevations in meters above sea level	2,000: P	2,000: T	2,000: R H	2,500: P	2,500: T	2,500: R H	3,000: P	3,000: T	3,000: R H	4,000: P	4,000: T	4,000: R H	5,000: P	5,000: T	5,000: R
Billings, Mont. (1090 m)	795	−1.5	51	746	−4.9	52	700	−8.2	53	614	−13.8	52	538	−19.9	50
Cheyenne, Wyo. (1873 m)	797	−2.1	60	748	−3.4	54	702	−5.7	52	617	−11.7	50	540	−18.9	48
Chicago, Ill. (187 m)	790	−5.9	58	741	−7.8	57	695	−10.5	58	609	−15.9	59	533	−22.0	58
Coco Solo, C. Z.[1] (15 m)	803	14.8	72	756	12.7	63	713	10.4	58	631	5.3	56	559	.3	43
El Paso, Tex. (1193 m)	802	6.9	41	754	4.1	42	709	1.3	43	625	−4.6	36	550	−10.7	31
Lakehurst, N. J.[1] (39 m)	792	−4.8	57	743	−6.6	51	697	−9.0	49	612	−14.6	48			
Norfolk, Va.[1] (10 m)	799	−0.4	62	751	−1.6	61	705	−3.9	57	620	−10.2	52	544	−17.8	51
Pearl Harbor, T. H.[1] (6 m)	805	14.2	60	758	12.8	47	715	11.0	38	633	6.6	27	560	0.9	25
Pensacola, Fla.[1] (13 m)	804	5.7	49	755	4.3	39	710	2.3	30	626	−3.5	22	551	−9.8	15
St. Thomas, V. I.[1] (8 m)	806	14.4	74	759	12.7	60	715	10.5	50	634	5.4	41	561	.4	30
Salt Lake City, Utah (1288 m)	801	−.9	71	752	−3.5	72	706	−6.1	71	621	−10.5	60	544	−16.8	55
San Diego, Calif.[1] (10 m)	802	7.5	56	754	4.9	53	708	2.0	51	625	−4.2	46	551	−11.6	43
Spokane, Wash. (597 m)	796	−3.3	68	747	−5.5	63	701	−8.3	64	616	−13.9	59	538	−20.0	50

[1] Navy.
Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5-standard-level observations.

TABLE 1a.—*Mean free-air barometric pressures (P) in mb., temperatures (T) in °C., and relative humidities (R. H.) in percent obtained by radiosonde during December 1938.*

Stations and elevations in meters above sea level

Altitude (meters) m. s. l.	Fargo, N. Dak. (274 m): Number of obs.	P	T	R H	Nashville, Tenn. (180 m): Number of obs.	P	T	R H	Oakland, Calif. (2 m): Number of obs.	P	T	R H
Surface	31	983	−10.2	90	31	999	2.7	76	31	1,020	8.2	87
500	31	954	−8.6	87	31	960	3.1	68	31	961	9.8	74
1,000	31	895	−7.5	81	31	902	1.6	68	31	905	9.4	66
1,500	31	839	−8.3	75	31	848	0.7	58	31	852	7.7	62
2,000	31	787	−9.5	71	31	797	−0.3	56	30	801	5.7	58
2,500	31	737	−11.7	68	30	748	−1.9	54	30	754	3.2	54
3,000	31	690	−13.9	65	30	702	−3.9	50	30	708	0.3	51
4,000	31	604	−19.1	63	30	618	−8.4	44	30	625	−6.0	47
5,000	31	528	−25.3	63	30	543	−14.9	41	30	549	−12.3	45
6,000	31	458	−31.9	61	30	475	−21.9	40	29	481	−19.3	45
7,000	31	398	−39.3	60	30	414	−29.1	36	29	420	−26.5	45
8,000	31	343	−47.1		30	359	−36.5	38	29	365	−34.3	44
9,000	28	294	−52.8		29	310	−42.9		29	315	−42.1	44
10,000	28	251	−54.9		29	267	−49.0		28	272	−48.6	
11,000	27	215	−54.7		29	229	−53.2		27	233	−53.4	
12,000	24	184	−53.7		27	196	−55.5		25	199	−57.1	
13,000	23	157	−54.0		27	167	−57.1		25	170	−58.7	
14,000	19	134	−54.5		23	142	−59.9		24	144	−60.0	
15,000	15	114	−56.1		22	121	−62.2		23	123	−61.6	
16,000	11	97	−57.0		17	103	−63.6		21	105	−62.7	
17,000	6	83	−58.2		13	88	−64.0		18	89	−62.7	
18,000					6	74	−64.6		13	76	−61.8	
19,000					5	63	−64.6					
20,000												

Altitude (meters) m. s. l.	Oklahoma City, Okla. (391 m): Number of obs.	P	T	R H	Omaha, Nebr. (300 m): Number of obs.	P	T	R H	Sault Ste. Marie, Mich. (221 m): Number of obs.	P	T	R H	Washington, D. C.[1] (13 m): Number of obs.	P	T	R H
Surface	31	973	1.8	69	31	982	−3.4	79	31	986	−5.0	90	30	1,019	1.2	78
500	31	959	4.1	66	31	958	−2.8	70	31	952	−6.2	91	30	959	0.7	66
1,000	31	902	4.9	56	31	899	−2.0	62	31	893	−8.7	93	30	901	−1.3	67
1,500	31	849	4.1	51	31	845	−2.7	58	31	837	−10.6	90	30	846	−1.8	67
2,000	30	798	2.6	47	31	792	−4.2	56	31	784	−12.1	83	30	794	−3.2	62
2,500	30	750	0.6	45	31	744	−6.6	54	31	734	−13.7	78	30	745	−4.8	60
3,000	30	704	−1.3	44	31	697	−9.1	53	31	687	−15.4	74	30	699	−6.7	58
4,000	30	620	−7.3	43	31	612	−14.5	51	31	601	−20.7	71	30	614	−11.1	53
5,000	30	545	−13.4	42	30	536	−20.9	52	31	524	−26.8	69	30	538	−17.3	52
6,000	30	477	−20.8	41	30	467	−27.6	51	31	456	−32.7	66	29	471	−23.4	54
7,000	30	416	−27.8	40	30	405	−34.8	50	31	394	−39.8	65	29	410	−29.6	54
8,000	28	361	−35.1	38	29	350	−42.1		30	340	−46.3		28	355	−36.0	
9,000	28	312	−42.1	39	29	302	−48.7		29	292	−51.2		27	307	−42.0	
10,000	27	268	−48.6		28	258	−53.4		29	250	−52.1		23	265	−48.0	
11,000	27	230	−53.6		28	221	−55.4		27	215	−51.1		21	227	−52.5	
12,000	26	197	−56.6		28	189	−56.0		26	184	−50.7		16	195	−55.2	
13,000	24	168	−59.0		27	161	−57.0		25	157	−51.6		15	166	−56.7	
14,000	20	143	−61.3		26	138	−58.6		23	135	−53.3		10	142	−58.5	
15,000	15	122	−63.6		26	117	−60.9		19	115	−54.6		9	121	−61.0	
16,000	10	103	−67.2		25	100	−62.5		14	98	−55.6		8	103	−62.9	
17,000	6	88	−68.4		22	84	−63.8		7	84	−56.7		6	87	−64.8	
18,000					17	72	−63.5						5	74	−66.1	
19,000					14	61	−62.9									
20,000					8	52	−62.2									

[1] Navy.
Observations taken about 4 a. m., 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels also the humidity data is not used in daily observations when the temperature is below −40° C.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during December 1938*

[Wind from N=360°, E=90°, etc.]

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (302 m)		Billings, Mont. (1,095 m)		Boston, Mass. (15 m)		Brooklyn, N. Y. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (157 m)		Detroit, Mich. (204 m)		Fargo, N. Dak. (283 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	341	1.4	317	1.6	245	4.2	264	2.1	297	3.2	279	5.1	254	2.1	253	0.9	252	2.1	298	1.8	30	0.9	45	3.1	98	0.4
500			305	2.0			287	6.4	306	6.0			259	3.8	242	3.3	255	4.5	308	2.9	175	2.2	70	4.6	31	0.2
1,000			290	4.0			300	7.9	301	7.8			268	6.4	257	8.0	260	6.3	303	6.5	260	4.0	106	2.5	135	1.9
1,500			279	6.0	267	8.3	304	10.8	288	8.8			269	8.6	258	9.8	275	8.5	292	8.0	261	6.7	232	0.8	154	4.9
2,000	299	2.3	274	8.2	282	10.6	299	11.6	280	10.6	283	7.3	268	10.3	268	9.5	289	9.5	294	10.5	275	7.4	255	2.0	166	3.6
2,500	293	6.2	277	10.4	294	10.7	290	11.9	280	13.5	293	13.2	271	12.3	272	9.7	293	10.5	294	10.1	278	8.7	268	2.9	174	4.3
3,000	291	8.7	290	11.3	295	11.2	282	13.1	279	14.5	300	12.3	271	13.6	276	9.1	305	6.7	282	7.7	271	8.5	253	3.5	168	3.7
4,000	290	11.4			310	7.2					300	11.8									302	10.3	242	4.3	98	4.1
5,000	289	12.6									282	10.9														

Altitude (meters) m. s. l.	Nashville, Tenn. (194 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha Nebr. (306 m)		Pear Harbor, T. H. (68 m)[1]		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)		Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	261	0.9	73	1.7	253	1.6	312	2.0			23	2.7	221	1.7	151	1.8	20	0.2	251	1.0	172	2.4	224	1.7	304	1.2
500	254	3.7	47	4.5	289	2.5	314	4.3			321	2.2	249	5.8			119	1.0	250	3.6	202	6.1			305	3.7
1,000	269	4.3	39	3.1	286	5.3	313	8.5			276	4.1	289	7.6			69	1.0	276	6.4	210	5.9	236	4.9	290	6.4
1,500	259	6.6	33	2.5	298	7.2	305	9.1			294	6.3	274	9.4	171	1.9	167	0.6	275	8.7	233	5.3	242	6.9	286	9.6
2,000	290	8.5	25	2.3	286	8.8	299	10.6			284	7.0	273	10.5	218	2.5	96	0.8			256	4.0	255	8.1	279	11.4
2,500	281	11.4	344	2.9	297	10.6	302	11.9			280	6.4	282	11.7	273	3.7	42	1.3			267	5.0	275	8.3	264	12.2
3,000	280	13.2	333	3.7	289	11.1	296	12.1			281	6.6	279	12.8	288	6.1	23	2.2			280	3.4	280	9.3	262	14.3
4,000	282	15.8	310	4.6	277	16.2	287	14.7			291	7.4	280	11.3	295	9.9	360	3.3			281	2.6	325	3.0		
5,000															274	11.4	323	3.5					345	11.3		

[1] Navy stations.

TABLE 3.—*Maximum free-air wind velocities (m. p. s.), for different sections of the United States based on pilot-balloon observations during December 1938*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station
Northeast [1]	42.6	WNW	2,360	12	Harrisburg, Pa.	42.0	W	2,860	31	Cleveland, Ohio	37.2	SW	6,110	5	Columbus, Ohio.
East-Central [2]	38.5	NW	2,500	28	Richmond, Va.	45.0	W	5,000	28	Nashville, Tenn.	53.2	W	5,140	28	Nashville, Tenn.
Southeast [3]	33.4	WSW	2,120	9	Tampa, Fla.	47.5	SW	3,540	9	Charleston, S. C.	43.6	WNW	9,840	2	Charleston, S. C.
North Central [4]	37.6	SSW	1,060	25	Minneapolis, Minn.	55.1	WNW	5,000	31	Fargo, N. Dak.	60.5	WNW	6,050	27	Fargo, N. Dak.
Central [5]	34.4	W	2,080	31	Chicago, Ill.	50.0	NW	4,950	18	Springfield, Ill.	76.8	W	9,000	12	Wichita, Kans.
South-Central [6]	36.6	WSW	2,500	26	New Orleans, La.	42.8	NNW	4,090	8	Amarillo, Tex.	68.0	WSW	9,810	23	Oklahoma City, Okla.
Northwest [7]	42.8	WSW	2,160	2	Pendleton, Oreg.	50.0	NW	5,000	25	Pendleton, Oreg.	50.8	NW	5,040	25	Pendleton, Oreg.
West-Central [8]	50.9	W	2,480	3	Cheyenne, Wyo.	48.0	W	2,670	3	Cheyenne, Wyo.	58.0	NW	9,240	8	Rock Springs, Wyo.
Southwest [9]	32.4	N	1,930	1	Burbank, Calif.	54.1	SW	5,000	15	Winslow, Ariz.	78.8	N	10,120	7	Albuquerque, N. Mex.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

AEROLOGICAL OBSERVATIONS FOR THE YEAR 1938

[Aerological Division, D. M. LITTLE in charge]

By B. FRANCIS DASHIELL

One of the most important advances in the aerological work of the Weather Bureau during 1938 was the development and increase in the use of radiosonde equipment. At the close of the year such observations were being conducted at six stations by the Weather Bureau; one by the Navy. These, as well as all airplane stations, are listed in table 1. This table includes annual mean free-air barometric pressures, temperatures, and relative humidities for standard levels up to 5 kilometers. A total of 4,621 airplane observations was made in the United States at the stations listed in table 1, and 62 percent reached 5 kilometers. Of the 945 radiosonde observations made since midsummer 20 percent reached an altitude of 20 kilometers.

Pilot-ballon observations of wind direction and velocity were being made from 2 to 4 times daily at 86 stations, including 4 in Alaska and 1 in San Juan, P. R., at the close of the year. This was an increase of 9 stations over the year 1937. As a safety measure helium gas was substituted for hydrogen at a number of places. At 15 stations having good visibility, new 100-gram-balloon observations were inaugurated. The ascensional rate of these balloons was determined after a long series of two-theodolite observations made at Washington. Since the 100-gram balloons reach higher altitudes than the 30-gram type in the same time, this accounts for many outstanding altitudes and wind speeds recorded on the monthly tables.

A series of observations with sounding balloons carrying recording meteorographs was conducted at Omaha, Nebr., in July. These flights were checked for the rate of ascent and wind directions and velocities by means of two theodolites, and a maximum altitude of 29 kilometers was attained.

Through the cooperation of the Works Progress Administration a program of assembling and reducing to punch cards all Weather Bureau pilot-balloon data and the summarization of airway surface records was inaugurated at New Orleans, La. It will be possible, in the future, quickly and accurately to summarize any of these aerological data for any period of time at any place, and thus make available to the needs of aviation much new material concerning surface conditions and upper-air winds.

The lowest mean free-air temperatures (°C.) for the year were recorded at the surface at Fargo, N. Dak., and over Sault Ste. Marie, Mich., at 0.5, 1, 1.5, 2, 2.5, 3, 4, and 5 kilometers. Maximum annual mean temperatures occurred at San Diego, Calif., at the surface, and 0.5 and 1 kilometer; over El Paso, Tex., at 1.5, 2, 2.5, and 3 kilometers; and over Pensacola, Fla., at 4 and 5 kilometers. For the country as a whole, January and February were the coldest months of 1938, but, in the South, above 2.5 kilometers, December became the coldest month.

Annual mean barometric pressure was lowest over Fargo, N. Dak., and Sault Ste. Marie, Mich.; particularly over the latter above 2 kilometers. At these places the lowest annual mean pressures occurred in December at 0.5, 1, 4, and 5 kilometers, and in January at 1.5, 2, 2.5, and 3 kilometers. High pressures prevailed over Pensacola, Fla., at all levels. Mean relative humidity was highest over Pensacola, Fla., at the surface; over San Diego, Calif., at 0.5 kilometer; over Sault Ste. Marie, Mich., at all other levels up to 4 kilometers; and over Billings, Mont., at 5 kilometers.

Above 5 kilometers all observations were obtained by radiosonde. But, since these observations are for a period of 5 months only, no annual means have been computed. Therefore, they are not included in table 1. However, monthly means indicate that the lowest temperatures prevailed over Fargo, N. Dak., and Sault Ste. Marie, Mich., upward to approximately 11 kilometers; over Omaha, Nebr., for the next 4 kilometers; and then over Nashville, Tenn., and Oklahoma City, Okla., at 15, 16, and 17 kilometers.

Individual low temperatures recorded by radiosonde in the higher levels during 1938 were: −66.3° C. and −72.0° C., at Fargo, N. Dak. (December); −70.7° C., at Omaha, Nebr. (December); −76.8° C., at Oklahoma City, Okla. (December); −73.7° C., at Washington, D. C. (August); −79.5° C. and −80.0° C. (July), and −89.8° C. and −80.0° C. (November), all over Oklahoma City, Okla.; and −78.0° C. and −78.9° C., over Washington, D. C. (November); at 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20 kilometers, respectively.

Radiosonde observations were made at Fairbanks, Alaska, during the winter months of January, February, and March, in connection with investigations of polar air masses. They showed individual low temperatures of −55.8° C., −56.5° C., −58.0° C., −58.2° C., −59.2° C., and −52.3° C., at 10, 11, 12, 13, 14, and 15 kilometers, respectively.

Resultant wind directions and velocities were computed at 25 selected stations during each month of 1938. These were based on 5 a. m. (75th meridian time) observations at all standard levels up to and including 5 kilometers. At these stations the resultant winds departed in various amounts throughout the year from their normals. Large departures in direction were noted over Medford, Oreg., Key West, Fla., Pensacola, Fla., Sault Ste. Marie, Mich., and Oakland, Calif. The annual average departures from normal for the combined levels showed average differences of 38.2°, 35.5°, 34.5°, 30.3°, and 27.7°, respectively. More nearly normal resultant directions were noted at Boston, Mass.; Cheyenne, Wyo.; St. Louis, Mo.; Chicago, Ill.; and Washington, D. C. The annual average differences between the actual wind directions and their normals were: 11.2°, 11.3°, 11.5°, 12.3°, and 12.8°, respectively.

The resultant-wind velocities for the year were slightly in excess of normal for the country as a whole at all levels. This was particularly noticeable for the months of January, March, May, August, November, and December. Velocities were somewhat less than normal in February, June, July, September, and October, and especially so during September.

Table 2 gives the maximum wind velocities reported in 1938. High velocities occurred over all areas with a number of records established at certain stations. The maximum velocity of 90 meters per second, recorded over Winslow, Ariz., at 12 kilometers on the 14th of November, was a new record for the United States.

TABLE 1.—*Mean free-air barometric pressures (P) in mb., temperatures (T) in °C., and relative humidities (R. H.) in percent obtained by airplanes and radiosonde during 1938*

Stations and elevations in meters above sea level	Altitude (meters) m. s. l.																											
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
	Number of obs.	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H	P	T	R/H
Airplanes																												
Billings, Mont. (1,090 m.)	355	891	6.3	65	----	----	----	----	----	----	848	8.3	54	798	5.8	53	750	2.5	55	705	−1.0	57	621	−7.5	58	545	−14.4	57
Cheyenne, Wyo. (1,873 m.)	353	811	4.3	70	----	----	----	----	----	----	----	----	----	799	6.5	61	751	5.1	55	707	2.0	53	623	−5.2	55	548	−12.6	56
Chicago, Ill. (187 m.)	362	994	8.4	81	957	9.3	72	901	7.8	69	848	6.0	66	797	4.0	62	749	1.6	56	704	−1.0	55	620	−6.7	51	545	−12.8	48
Coco Solo, C. Z.[1] (15 m.)	317	1,009	24.8	89	955	23.1	86	902	20.3	85	851	17.6	81	802	15.2	75	756	13.2	65	712	10.8	59	631	5.2	57	558	−0.3	52
El Paso, Tex. (1,193 m.)	354	882	13.2	49	----	----	----	----	----	----	851	15.5	41	802	13.0	41	755	9.8	43	711	6.3	44	628	−0.7	46	553	−7.5	45
Lakehurst, N. J.[1] (39 m.)	276	1,014	8.5	83	958	10.2	63	902	7.5	60	848	5.2	60	798	2.8	56	750	0.4	51	704	−2.4	48	619	−8.6	45	----	----	----
Norfolk, Va.[1] (10 m.)	236	1,019	12.9	84	962	13.5	65	906	11.1	60	853	8.9	58	803	6.7	56	755	4.5	52	705	2.1	48	626	−3.6	43	551	−10.0	40
Pearl Harbor, T. H.[1] (6 m.)	365	1,015	21.9	82	959	21.1	76	905	18.1	80	853	15.6	77	804	13.8	66	757	12.7	50	713	10.9	39	632	6.6	29	559	1.4	27
Pensacola, Fla.[1] (13 m.)	323	1,018	16.2	88	962	17.3	69	907	15.1	64	855	12.7	59	805	10.4	53	757	8.2	46	713	5.8	40	630	0.4	35	556	−5.5	32
St. Thomas, V. I.[1] (8 m.)	350	1,016	26.0	74	961	21.8	84	907	18.4	85	855	15.6	81	806	13.4	74	759	11.8	60	715	9.5	51	633	4.1	43	560	−1.4	38
Salt Lake City, Utah (1,288 m.)	365	872	7.7	67	----	----	----	----	----	----	850	10.4	54	800	8.2	51	752	5.0	53	708	1.6	55	624	−4.9	58	549	−11.8	58
San Diego, Calif.[1] (10 m.)	346	1,015	13.6	84	958	14.0	78	903	14.9	60	851	13.4	51	801	11.0	46	754	8.4	43	709	5.5	41	627	−0.8	38	553	−8.0	37
Seattle, Wash.[1] (10 m.)[2]	224	1,017	12.0	72	959	10.0	70	903	8.6	62	850	6.4	56	799	3.9	52	751	1.2	47	706	−1.5	42	----	----	----	----	----	----
Spokane, Wash. (597 m.)	365	946	6.6	77	----	----	----	901	8.9	62	848	6.9	59	798	3.9	59	750	0.7	60	704	−2.5	60	620	−8.8	58	544	−15.2	56
Radiosonde																												
Fargo, N. Dak. (274 m.)[3]	334	982	1.1	81	955	3.4	74	898	3.6	68	844	2.3	64	793	0.5	61	745	−1.8	60	699	−4.4	58	615	−10.0	56	539	−16.1	55
Nashville, Tenn. (180 m.)[3]	332	997	11.8	81	960	13.2	71	904	11.4	69	851	9.1	65	801	6.9	61	753	4.5	58	708	1.9	53	625	−3.6	48	550	−9.9	46
Oakland, Calif. (2 m.)[3]	333	1,017	10.8	84	958	11.6	72	903	12.2	58	850	10.2	52	800	7.7	48	752	5.0	45	706	2.1	43	624	−4.2	42	549	−10.7	41
Oklahoma City, Okla. (391 m.)[3]	328	971	11.7	74	958	13.3	68	903	13.6	59	851	12.1	55	801	9.7	51	754	6.9	50	709	3.9	48	626	−2.4	47	551	−8.9	44
Omaha, Nebr. (300 m.)[3]	331	980	7.5	79	957	8.8	70	901	9.0	62	848	7.5	58	798	5.2	55	750	2.7	53	705	−0.2	52	621	−6.5	51	546	−13.2	50
Sault Ste. Marie, Mich. (221 m.)[3]	319	989	1.6	86	956	2.1	80	898	0.9	76	844	−0.8	72	792	−2.7	68	743	−4.7	66	698	−6.8	63	612	−12.0	58	537	−18.0	56
Washington, D. C.[1] (13 m.)[4]	339	1,018	10.7	82	960	10.8	69	904	8.9	66	850	6.7	66	800	4.6	64	752	2.4	59	707	0.0	56	622	−5.5	51	548	−11.6	47

Observations taken about 4 a. m., 75th meridian time, except by Navy stations along the Pacific coast and Hawaii, where they are taken at dawn.

[1] Navy.

[2] Yearly means based on 11 months. Month of December 1938 not included due to insufficient number of observations.

[3] Yearly means based on 11 months. Airplane flights ended June 30, 1938, and radio sonde flights started latter part of July, but not sufficient number of observations to compute a mean for that month.

[4] Radiosonde flights started in June 1938.

TABLE 2.—*Maximum free-air wind velocities (meters per second), for different sections of the United States based on pilot balloon observations during the year 1938*

Section	Surface to 2,500 meters (m. s. l.)						Between 2,500 and 5,000 meters (m. s. l.)						Above 5,000 meters (m. s. l.)					
	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Month	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Month	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Month	Station
Northeast [1]	50.1	SSW	1,240	24	Jan.	Cleveland, Ohio	52.1	NNW	2,950	28	Feb.	Kylertown, Pa.	50.2	NW	9,520	28	Mar.	Cleveland, Ohio.
East Central [2]	55.8	WNW	2,500	14	Nov.	Washington, D. C	69.1	WNW	2,620	14	Nov.	Washington, D. C	53.2	W	5,140	28	Dec.	Nashville, Tenn.
Southeast [3]	38.2	WSW	2,080	25	Jan.	Jacksonville, Fla	47.5	SW	3,540	9	Dec.	Charleston, S. C	48.8	WSW	6,150	25	Nov.	Atlanta, Ga.
North Central [4]	49.1	W	820	14	Nov.	Detroit, Mich	57.6	WSW	4,800	13	May	Huron, S. Dak	62.0	SW	8,570	3	Nov.	Fargo, N. Dak.
Central [5]	43.0	SSE	2,080	12	Nov.	Chicago, Ill	50.0	NW	4,950	18	Dec.	Springfield, Ill	76.8	W	9,000	12	Dec.	Wichita, Kans.
South Central [6]	49.6	SW	1,930	28	Jan.	Oklahoma City, Okla.	74.6	NNW	4,590	25	Jan.	Abilene, Tex	68.0	WSW	9,810	23	Dec.	Oklahoma City, Okla.
Northwest [7]	46.2	SSW	2,300	5	Feb.	Medford, Oreg	69.8	SSW	2,660	11	Aug.	Havre, Mont	59.2	NE	9,380	8	Oct.	Billings, Mont.
West Central [8]	63.3	S	2,470	19	June	Modena, Utah	58.0	S	2,500	19	June	Modena, Utah	78.0	SW	7,960	17	Oct.	Denver, Colo.
Southwest [9]	47.8	W	1,940	19	Mar.	Havre, Mont	70.0	WSW	4,700	4	Mar.	Albuquerque, N. Mex.	90.0	WSW	12,020	14	Nov.	Winslow, Ariz.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.

[2] Delaware, Maryland, Virgini., West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.

[3] South Carolina, Georgia, Florida, and Alabama.

[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.

[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.

[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.

[7] Montana, Idaho, Washington, and Oregon.

[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.

[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By THOMAS S. SOUTHWICK

Precipitation during December 1938 was generally less than normal except in New England, Michigan, and the Southwestern States. Floods were minor and were confined to the extreme eastern and western parts of the country.

Moderate to heavy rains over the Coast Range in northern California and Oregon the first three days of the month caused high stages in that region. Flood stages were reached only on the Santiam River in Oregon and on the Eel River in northern California on the 3d. Flooding on the former was slight and no damage resulted; on the Eel River damage is estimated at $19,000.

The abnormal snowfall in the last week of November over the Northeast, followed by above-normal temperatures and moderate rains caused threatening stages during the first week of December. Floods occurred on the Pemigewasset, Merrimack, and Connecticut Rivers in New England, the Susquehanna and Chenango Rivers in New York, and the Lackawaxen River in Pennsylvania during the period December 6 to 11. None of the floods was serious.

The longest period above flood stage was at Hartford, Conn., where the Connecticut River went above flood stage on the 7th and remained until December 13. The crest was on the 8th, with a stage of 19.1, or 3.1 feet above flood stage. The only damage reported was in the vicinity of Hartford and was confined to shipping which was delayed.

In the Susquehanna River basin there were two periods of high stages; from the 5th to the 8th and from the 10th to the 13th of December. The Susquehanna River went above flood stage during both periods, and during the latter rise, the Chenango River went above flood stage. Damage on the Susquehanna was reported as amounting to $700, and on the Chenango, $375. It is estimated that $8,200 was saved because of the Weather Bureau's warnings.

The Lackawaxen River went 2 feet over flood stage on December 6th, when the melting of ice caused a rapid rise. No damage was reported.

Table of flood stages during December 1938
[All dates in December]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE	*Feet*			*Feet*	
Merrimack: Concord, N. H	12	7	7	12.7	7
Connecticut:					
South Newbury, Vt	22	7	7	22.1	7
Hartford, Conn	16	7	13	19.1	8
Lackawaxen: Hawley, Pa	6	6	6	8.1	6
Chenango:					
Sherburne, N. Y	8	10	10	8.3	10
Greene, N. Y	8	10	11	8.6	11
Susquehanna:					
Oneonta, N. Y	12	6 10	8 13	15.3 15.0	6 11
Vestal, N. Y	12	6 10	8 13	15.6 17.2	6 11
Cape Fear: Elizabethtown, N. C	20	29	29	21.9	29
Broad: Blairs, S. C	14	28	28	14.6	28
PACIFIC SLOPE DRAINAGE					
Eel: Fernbridge, Calif	17.5	3	3	18.8	3
Columbia Basin					
Santiam: Jefferson, Oreg	10	3	3	10.3	3

Locally heavy rains in the Carolinas on December 27 caused small rises on the Broad and Cape Fear Rivers on the 28th and 29th, respectively. There was no damage reported.

A report on the September 1938 flood on the Connecticut River will be in an early issue of the MONTHLY WEATHER REVIEW.

ESTIMATED FLOOD LOSSES DURING 1937 [1]

The estimated flood losses in the United States during 1937 were the greatest of any year of which the Weather Bureau has records, and amounted to $440,739,529 and 157 lives lost. Of this total, the greater part, $417,685,557 and 137 deaths, was caused by the unprecedented flood in the Ohio and lower Mississippi Valleys during January and February and is the greatest loss of record from any one single major flood. A comparative table of flood losses for a few of the greatest individual floods of recent years follows:

Month and year	Region	Damage	Lives lost
January-February 1937	Ohio and lower Mississippi	$417,685,557	137
Spring 1927	Mississippi Valley	284,117,631	313
March 1936	Eastern United States	[1] 270,000,000	107
March 1913	Ohio and lower Mississippi	154,000,000	467

[1] Incomplete.

The following tables are statements of estimated flood losses, and savings effected by Weather Bureau flood warnings in the year 1937.

Statement of estimated tangible flood losses during January–February flood in Ohio and lower Mississippi Basins

	Monetary loss [1]	Lives lost [2]
Ohio Basin:		
Illinois	$17,400,000	10
Indiana	55,000,000	9
Ohio	88,300,000	10
Pennsylvania	4,700,000	0
West Virginia	21,000,000	6
Kentucky	219,800,000	22
Tennessee	5,000,000	8
Total	411,200,000	65
Lower Mississippi Basin	6,485,557	72
Grand total	417,685,557	137

[1] From data furnished by the Corps of Engineers, U. S. Army.
[2] From vital statistics of the American Red Cross.

ST. LAWRENCE DRAINAGE

SANDUSKY RIVER IN OHIO

Tangible property totally or partially destroyed	$20,000
Matured crops	50,000
Prospective crops	560,000
Livestock and other movable farm property	49,000
Suspension of business, including wages of employees	11,500
Total	690,500

ATLANTIC SLOPE DRAINAGE

TIOUGHNIOGA RIVER IN NEW YORK

Suspension of business, including wages of employees	600

CHENANGO RIVER IN NEW YORK

Tangible property, totally or partially destroyed	380
Matured crops	200
Suspension of business, including wages of employees	625

[1] Exclusive of losses in January-February flood in the Ohio and lower Mississippi Basins.

JUNIATA RIVER IN PENNSYLVANIA

Tangible property, totally or partially destroyed	$190,000
Prospective crops	5,000
Livestock and other movable farm property	40,200
Suspension of business, including wages of employees	13,400

SUSQUEHANNA RIVER IN NEW YORK

Tangible property totally or partially destroyed	200
Matured crops	100
Suspension of business, including wages of employees	675

SUSQUEHANNA RIVER IN PENNSYLVANIA

Tangible property totally or partially destroyed	595,000
Prospective crops	50,000

PATUXENT RIVER AND CHESAPEAKE BAY

Tangible property totally or partially destroyed	33,382
Matured crops	175
Prospective crops	4,650
Livestock and other movable farm property	400

POTOMAC RIVER

Tangible property totally or partially destroyed	1,170,335
Matured crops	13,100
Prospective crops	133,725
Livestock and other movable farm property	24,390

RAPPAHANNOCK AND YORK RIVERS IN VIRGINIA

Tangible property totally or partially destroyed	350,363
Matured crops	2,228
Prospective crops	54,448
Livestock and other movable farm property	6,000

JAMES RIVER IN VIRGINIA

Tangible property totally or partially destroyed	502,000

ROANOKE RIVER IN VIRGINIA AND NORTH CAROLINA

Tangible property totally or partially destroyed	49,500
Matured crops	61,150
Prospective crops	22,500
Livestock and other movable farm property	2,800
Suspension of business, including wages of employees	135,650

NEUSE RIVER IN NORTH CAROLINA

Tangible property totally or partially destroyed	3,200
Matured crops	600
Prospective crops	5,500
Livestock and other movable farm property	750
Suspension of business, including wages of employees	13,000

TAR RIVER IN NORTH CAROLINA

Tangible property totally or partially destroyed	1,650
Matured crops	500
Prospective crops	4,000
Livestock and other movable farm property	300
Suspension of business, including wages of employees	7,000

CAPE FEAR RIVER IN NORTH CAROLINA

Tangible property totally or partially destroyed	slight
Prospective crops	1,000
Suspension of business, including wages of employees	8,500

PEEDEE RIVER IN SOUTH CAROLINA

Prospective crops	15,000
Suspension of business, including wages of employees	14,500

SALUDA RIVER IN SOUTH CAROLINA

Tangible property totally or partially destroyed	25,000
Matured crops	12,500
Prospective crops	500

CATAWBA-WATEREE RIVERS IN SOUTH CAROLINA

Tangible property totally or partially destroyed	1,000
Matured crops	3,000
Prospective crops	5,000
Suspension of business, including wages of employees	500

BROAD RIVER IN SOUTH CAROLINA

Matured crops	$300
Prospective crops	2,700

CONGAREE RIVER IN SOUTH CAROLINA

Prospective crops	1,000

SANTEE RIVER IN SOUTH CAROLINA

Tangible property totally or partially destroyed	75
Prospective crops	140
Livestock and other movable farm property	400
Suspension of business, including wages of employees	18,200

SAVANNAH AND OGEECHEE RIVERS IN GEORGIA

Tangible property totally or partially destroyed	550
Livestock and other movable farm property	800
Suspension of business, including wages of employees	8,900

ALTAMAHA RIVER SYSTEM IN GEORGIA

Tangible property totally or partially destroyed	1,250
Matured crops	1,000
Prospective crops	19,000
Livestock and other movable farm property	10,800
Suspension of business, including wages of employees	28,000
Total	3,679,291

East Gulf of Mexico Drainage

APALACHICOLA RIVER IN FLORIDA

Tangible property totally or partially destroyed	8,500
Prospective crops	1,500
Suspension of business, including wages of employees	11,000

PEA RIVER IN ALABAMA

Tangible property totally or partially destroyed	7,500
Matured crops	9,000
Suspension of business, including wages of employees	3,500

CHOCTAWHATCHEE RIVER IN ALABAMA

Tangible property totally or partially destroyed	16,000
Matured crops	31,000
Prospective crops	7,220
Supsension of business, including wages of employees	300

CONNECUH RIVER IN ALABAMA

Tangible property totally or partially destroyed	8,000
Matured crops	2,100
Prospective crops	10,000
Livestock and other movable farm property	1,250
Suspension of business, including wages of employees	2,200

ALABAMA RIVER IN ALABAMA

Livestock and other movable farm property	3,000

BLACK WARRIOR AND TOMBIGBEE RIVER IN ALABAMA

Tangible property totally or partially destroyed	17,260
Prospective crops	97,750
Livestock and other movable farm property	7,900
Suspension of business, including wages of employees	65,000

PASCAGOULA RIVER IN MISSISSIPPI

Tangible property totally or partially destroyed	400
Prospective crops	100
Livestock and other movable farm property	400
Suspension of business, including wages of employees	9,500

PEARL RIVER IN MISSISSIPPI

Tangible property totally or partially destroyed	25,000
Livestock and other movable farm property	2,000
Suspension of business, including wages of employees	10,200
Total	357,580

Upper Mississippi System

REDWOOD RIVER IN MINNESOTA

Tangible property totally or partially destroyed	$6,000
Livestock and other movable farm property	1,000

ROCK RIVER IN ILLINOIS AND WISCONSIN

Tangible property totally or partially destroyed	310,282
Matured crops	24,610
Prospective crops	297,260
Livestock	2,500
Suspension of business including wages of employees	90,163

GALENA RIVER IN ILLINOIS

Tangible property totally or partially destroyed	150,000

MAQUOKETA AND WAPSIPINNICON RIVERS IN IOWA

Tangible property totally or partially destroyed	150,000
Livestock and other movable farm property	1,000
Suspension of business, including wages of employees	3,000

IOWA AND CEDAR RIVERS IN IOWA

Tangible property totally or partially destroyed	10,000
Matured crops	300
Livestock and other movable farm property	1,900
Suspension of business, including wages of employees	1,100

DES MOINES RIVER IN IOWA

Tangible property totally or partially destroyed	25,750
Matured crops	1,250
Prospective crops	6,450
Livestock and other movable farm property	6,300
Suspension of business, including wages of employees	5,340

ILLINOIS RIVER IN ILLINOIS

Prospective crops	25,000

BOURBEUSE RIVER IN MISSOURI

Matured crops	8,000
Total	1,127,205

Missouri Basin

BEAVERHEAD RIVER IN MONTANA

Tangible property totally or partially destroyed	4,000

YELLOWSTONE RIVER AT BILLINGS, MONT.

Total	750,000

CHEYENNE RIVER IN SOUTH DAKOTA

Tangible property totally or partially destroyed	140,535

BELLE FOURCHE AND WHITE RIVERS IN SOUTH DAKOTA

Tangible property totally or partially destroyed	66,300
Matured crops	15,000
Prospective crops	40,000

BIG SIOUX RIVER IN IOWA

Tangible property totally or partially destroyed	78,000
Matured crops	1,500
Prospective crops	10,000
Livestock and other movable farm property	3,300
Suspension of business, including wages of employees	12,000

FLOYD RIVER IN IOWA

Tangible property totally or partially destroyed	30,000
Prospective crops	14,000
Livestock and other movable farm property	500

SOLOMON RIVER IN KANSAS

Tangible property totally or partially destroyed	1,000
Matured crops	1,000
Prospective crops	10,000

REPUBLICAN RIVER IN KANSAS

Tangible property totally or partially destroyed	$4,000

GRAND RIVER IN IOWA

Tangible property totally or partially destroyed	3,000

GRAND RIVER IN MISSOURI

Tangible property totally or partially destroyed	3,200
Prospective crops	4,000

OSAGE RIVER IN MISSOURI

Tangible property totally or partially destroyed	5,000
Matured crops	20,500
Prospective crops	9,000
Livestock and other movable farm property	5,000
Suspension of business, including wages of employees	6,000

MISSOURI RIVER

Tangible property totally or partially destroyed	3,000
Matured crops	21,500
Prospective crops	105,500
Livestock and other movable farm property	1,125
Total	1,367,960

Ohio Basin

ALLEGHENY RIVER IN PENNSYLVANIA

Tangible property totally or partially destroyed	240,000
Matured crops	1,000
Prospective crops	30,000
Livestock and other movable farm property	1,500
Suspension of business, including wages of employees	80,000

MONONGAHELA RIVER IN PENNSYLVANIA

Tangible property totally or partially destroyed	163,500
Matured crops	50,000
Prospective crops	12,000
Suspension of business, including wages of employees	652,400

MUSKINGUM RIVER IN OHIO

Tangible property totally or partially destroyed	135,000
Matured crops	57,000
Prospective crops	512,000
Livestock and other movable farm property	500
Suspension of business, including wages of employees	8,000

LITTLE KANAWHA RIVER IN WEST VIRGINIA

Tangible property totally or partially destroyed	10,000
Matured crops	2,000
Prospective crops	7,000
Livestock and other movable farm property	1,000

SCIOTO RIVER IN OHIO

Tangible property totally or partially destroyed	5,000
Prospective crops	95,000

WEST FORK OF WHITE RIVER IN INDIANA

Matured crops	300

WHITE RIVER IN INDIANA

Matured crops	1,600
Prospective crops	5,000
Suspension of business, including wages of employees	500

WABASH RIVER IN INDIANA

Tangible property totally or partially destroyed	200
Prospective crops	7,000
Suspension of business, including wages of employees	300

FRENCH BROAD RIVER IN NORTH CAROLINA

Matured crops	1,000
Prospective crops	2,500

NORTH FORK OF HOLSTON RIVER IN TENNESSEE

Matured crops	$1,850

OHIO RIVER (PITTSBURGH DISTRICT)

Tangible property totally or partially destroyed	245,000
Prospective crops	115,000
Livestock and other movable farm property	2,000
Suspension of business, including wages of employees	183,326

OHIO RIVER (EVANSVILLE DISTRICT)

Tangible property	2,000
Prospective crops	65,000
Livetock and other movable farm property	1,000
Suspension of business, including wages of employees	2,000

OHIO RIVER (CAIRO DISTRICT)

Tangible property	1,500
Prospective crops	31,200
Livestock and other movable farm property	250
Suspension of business, including wages of employees	5,450
Total	2,736,876

WHITE BASIN

BLACK RIVER IN MISSOURI

Tangible property	10,200
Prospective crops	1,000
Livestock and other movable farm property	2,000
Suspension of business, including wages of employees	50,150

BLACK RIVER IN ARKANSAS

Prospective crops	1,000

WHITE RIVER IN MISSOURI AND ARKANSAS

Tangible property	26,000
Prospective crops	23,400
Livestock and other movable farm property	2,000
Suspension of business, including wages of employees	31,000
Total	146,750

ARKANSAS BASIN

CIMARRON RIVER IN OKLAHOMA

Prospective crops	15,000

NINNESCAH RIVER IN KANSAS

Tangible property	150,000
Matured crops	6,000
Prospective crops	12,000

NEOSHO RIVER IN KANSAS

Tangible property totally or partially destroyed	16,500
Matured crops	15,000
Prospective crops	25,000
Livestock or other movable farm property	10,000

NORTH CANADIAN RIVER IN OKLAHOMA

Tangible property totally or partially destroyed	253,000
Matured crops	9,800
Prospective crops	68,600
Livestock and other movable farm property	1,500
Suspension of business, including wages of employees	3,200

CANADIAN RIVER IN NEW MEXICO

Tangible property totally or partially destroyed	1,500
Suspension of business, including wages of employees	5,300

CANADIAN RIVER IN OKLAHOMA

Tangible property totally or partially destroyed	520,000
Matured crops	74,100
Prospective crops	186,500
Livestock and other movable farm property	3,200
Suspension of business, including wages of employees	35,000
Total	1,411,200

RED BASIN

OUACHITA RIVER IN ARKANSAS

Tangible property totally or partially destroyed	$2,500
Livestock and other movable farm property	2,900
Suspension of business, including wages of employees	7,700

SULPHUR RIVER IN TEXAS

Tangible property, totally or partially destroyed	250
Suspension of business, including wages of employees	11,500
Total	24,850

LOWER MISSISSIPPI BASIN

MISSISSIPPI RIVER

Tangible property totally or partially destroyed	8,000
Prospective crops	150,000
Livestock and other movable farm property	4,000
Suspension of business, including wages of employees	10,000
Total	172,000

WEST GULF OF MEXICO

TRINITY RIVER IN TEXAS

Livestock and other movable farm property	5,000

PECOS RIVER IN NEW MEXIOO

Tangible property totally or partially destroyed	214,000
Matured crops	65,500
Prospective crops	700,000
Livestock and other movable farm property	6,500
Suspension of business, including wages of employees	1,600

RIO GRANDE IN NEW MEXICO

Tangible property totally or partially destroyed	310,000
Matured crops	60,000
Prospective crops	450,000
Livestock and other movable farm property	10,500
Suspension of business, including wages of employees	7,000
Total	1,830,100

GULF OF CALIFORNIA DRAINAGE
COLORADO BASIN

GUNNISON RIVER IN COLORADO

Tangible property totally or partially destroyed	108,000
Matured crops	1,000
Prospective crops	100,000
Livestock and other movable farm property	2,000

WILLIAMS RIVER IN ARIZONA

Tangible property totally or partially destroyed	18,000
Suspension of business, including wages of employees	135

GILA RIVER AND TRIBUTARIES IN ARIZONA

Tangible property totally or partially destroyed	28,750
Prospective crops	6,500
Total	264,385

PACIFIC SLOPE DRAINAGE

SAN JOAQUIN RIVER IN CALIFORNIA

Tangible property totally or partially destroyed	651,650
Prospective crops	1,180,000
Suspension of business, including wages of employees	5,000

SACRAMENTO RIVER IN CALIFORNIA

Tangible property totally or partially destroyed	4,980,900
Matured crops	575,350
Prospective crops	842,000
Livestock and other movable farm property	773,800
Suspension of business, including wages of employees	99,200

WILLAMETTE RIVER IN OREGON

Tangible property totally or partially destroyed	$80, 300
Matured crops	7, 000
Prospective crops	12, 000
Livestock and other movable farm property	3, 075
Suspension of business, including wages of employees	35, 000
Total	9, 245, 275
Total, exlusive of Ohio-Mississippi flood	23, 053, 972
Total loss in Ohio River Basin, January-February	411, 200, 000
Total loss in lower Mississippi Basin, January-February	6, 485, 557
Grand total	440, 739, 529

Estimated savings from flood warnings during 1937

ATLANTIC SLOPE DRAINAGE

Tioughnioga River in New York	$1, 500
Chenango River in New York	3, 620
Susquehanna River	1, 500
Roanoke River	255, 000
Tar River in North Carolina	8, 000
Neuse River in North Carolina	26, 500
Cape Fear River in North Carolina	22, 500
Peedee River in South Carolina	36, 000
Saluda River in South Carolina	1, 500
Broad River in South Carolina	7, 000
Congaree River in South Carolina	3, 000
Catawba-Wateree River	20, 000
Santee River	26, 000
Savannah and Ogeechee Rivers	75, 000
Altamaha River	86, 000
Total	573, 120

EAST GULF OF MEXICO DRAINAGE

Apalachicola River	4, 000
Conecuh River	2, 000
Alabama River	8, 000
Black Warrior-Tombigbee River	79, 000
Pascagoula River	15, 300
Pearl River	22, 500
Total	130, 800

MISSISSIPPI SYSTEM

UPPER MISSISSIPPI BASIN

Rock River in Illinois and Wisconsin	30, 000
Maquoketa and Wapsipinnicon Rivers in Iowa	5, 000
Iowa and Cedar Rivers in Iowa	2, 500
Des Moines River	117, 000
Total	154, 500

MISSOURI BASIN

Big Sioux River	10, 000
Grand River in Missouri	27, 500
Osage River	10, 000
Missouri River	24, 000
Total	71, 500

OHIO BASIN

Allegheny River	$230, 000
Monongahela River	235, 000
Muskingum River	100, 000
West Fork of White River	64, 000
East Fork of White River	55, 000
White River in Indiana	558, 000
Wabash River	526, 000
Cumberland River	128, 600
French Broad River	1, 000
Tennessee River	53, 000
Ohio River and minor tributaries	55, 532, 850
Total	57, 483, 450

WHITE BASIN

Black River in Missouri	6, 000
Black River in Arkansas	15, 000
White River in Arkansas	642, 000
Total	663, 000

ARKANSAS BASIN

Cimarron River	12, 000
Ninnescah River in Kansas	5, 500
Neosho River	15, 000
North Canadian River	6, 000
Canadian River	105, 500
Petit Jean River	500
Arkansas River	10, 000
Total	154, 500

RED BASIN

Ouachita River	135, 000
Sulphur River	7, 100
Red River	7, 500
Total	149, 600

LOWER MISSISSIPPI BASIN

Mississippi River and minor tributaries	3, 021, 500
Total for Mississippi system	61, 698, 050

WEST GULF OF MEXICO DRAINAGE

Trinity River	15, 000
Pecos River in New Mexico	155, 000
Rio Grande in New Mexico	165, 000
Total	335, 000

PACIFIC SLOPE DRAINAGE

SACRAMENTO BASIN

Sacramento River	2, 283, 550

COLUMBIA BASIN

Willamette River	35, 150
Total Pacific Slope Drainage	2, 318, 700
Grand Total	65, 055, 670

Flood losses and savings for 1938 will be published in an early issue.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, WILLIS E. HURD, acting in charge]

NORTH ATLANTIC OCEAN, DECEMBER 1938

By H. C. HUNTER

Atmospheric pressure.—The pressure averages of December were below normal over more than half of the North Atlantic, though slightly above over some southeastern areas and from the vicinity of the Azores to waters near Newfoundland and eastern Canada. The northeastern portion of the ocean showed the largest deficiencies of pressure, but none of the selected stations had an unusually large departure for a winter month, −0.16 inch being the greatest, at Julianehaab, Greenland, and Valencia, Ireland.

During the first 17 days pressure was for the most part below normal, and often much below, over northeastern and north-central regions. Thereafter for a few days, centering about the 20th, low pressure prevailed over a belt in lower latitudes from Bermuda to southwestern Europe.

The pressure extremes noted in the available vessel reports were 30.66 and 28.42 inches. The higher reading was recorded during the forenoon of the 17th by the Danish steamship *Svanhild*, a short distance to southeastward of Cape Breton Island. The lower reading was noted early on the 12th, near 52° N., 42° W., by the German steamer *Bockenheim*.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, December 1938*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.32	−0.16	30.04	29	28.76	17
Reykjavik, Iceland	29.35	−.12	30.09	23	28.44	5
Lerwick, Shetland Islands	29.71	−.01	30.59	19	28.79	1
Valencia, Ireland	29.78	−.16	30.45	25	28.94	10
Lisbon, Portugal	30.02	−.09	30.39	5	29.21	11
Madeira	30.09	.00	30.33	5	29.71	21
Horta, Azores	30.19	+.05	30.50	16	29.74	20
Belle Isle, Newfoundland	29.79	+.05	30.44	27	28.84	7
Halifax, Nova Scotia	29.97	+.02	30.54	17	29.50	13
Nantucket	30.03	−.02	30.59	3	29.26	6
Hatteras	30.10	−.03	30.56	28	29.60	6
Bermuda	30.07	−.05	30.36	4	29.66	22
Turks Island	30.00	−.03	30.14	28	29.82	15, 16, 17
Key West	30.06	−.02	30.26	10	29.84	15
New Orleans	30.15	+.02	30.54	27	29.63	26

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—Though by no means so stormy as December 1934, yet the North Atlantic weather of December 1938 was stormier than during any of the three Decembers next preceding it. When different portions of the month are compared, it appears the final fortnight was the least disturbed part; the last week, particularly in central and eastern longitudes, included scarcely a gale of any consequence.

A storm centered near the Bay of Fundy when the month began traveled northeastward across Newfoundland, gaining in strength, and on the morning of the 3d was centered near 57° N., 37° W.; it continued thence northeastward to the waters between Iceland and southern Greenland on the 4th. Thereafter for a few days it centered near Iceland, with no great change in intensity. Two German steamers, *Heddernheim* and *Bockenheim*, on the 3d and 4th respectively, noted winds of hurricane force within the far-northern area dominated by this cyclone.

A following LOW, which was well developed when central over Labrador on the 7th, moved first northeastward but later eastward till, on the 9th, the center was near 55° N., 20° W. Much shipping was affected by the storm that day, though it was now less intense than when over Labrador. The American steamship *Black Eagle* met force-11 winds on the 9th. For a few days the LOW center remained west of the British Isles, but a LOW trough developed to southward, and within this trough, between Madeira and southern Portugal, very early on the 11th, the Dutch steamship *Arundo* met intense shifting winds which at one time reached hurricane force. The trough soon drew away to northward, making the LOW system more compact.

Within the 6-day period starting the 11th, a series of well-developed LOWS, in rapid succession, advanced from waters near America to unite with the system which hovered over the area west of the British Isles. Several vessels reported force-11 winds encountered in the chief shipping lanes to northwestern Europe as the result of one or other of these cyclones, and two vessels met force-12 winds, the *Black Eagle*, early on the 12th, near 48° N., 42° W., and, considerably to southeastward of that position, the American steamer *H. D. Collier*, during the evening of the 14th. Finally about the 17th, the LOW system moved away to northward and eastward as high pressure advanced eastward and southeastward from the Canadian coastal waters.

A feeble LOW, noted on the north-central Caribbean Sea on the 14th, moved northward over Haiti and the Bahamas and gained sufficient force by the 16th to cause whole gales over the waters east and northeast of the Bahamas. The center passed northwest of Bermuda during the night of the 17–18th, and near the southeastern edge of the Grand Banks on the 19th, where it merged with a moderately strong LOW system in high latitudes.

There was one later occurrence of wind of hurricane force, the British steamer *Trentbank* meeting this early on the 24th. The location was in unusually low latitude for the winter season, as had been the *Arundo's* encounter on the 11th, but the *Trentbank* was in 34° N., 40° W., or farther west than the Azores. A LOW which was not then intense had crossed New Jersey on the 21st, but within 2 days the center had moved to a position not far east of Newfoundland and had grown much stronger, while a trough of low pressure had developed, reaching far to the southward. The *Trentbank's* encounter was within this trough.

One tragedy nearly resulted from this storm. The Norwegian steamer *Smaragd*, from Norfolk, December 15, for Scotland, was disabled near 38° N., 62° W., on the 22d; boats from the American steamer *Schodack* succeeded in removing all 20 persons on board. The LOW system soon moved away to northward, and the chief sea routes were left in comparatively quiet condition for the remainder of the month.

Fog.—In the general region of the Grand Banks, fog was nearly everywhere of somewhat more frequent occurrence than usual in December, the first and third weeks bringing more than the other portions of the month. Here the 5°-square, 40° to 45° N., 45° to 50° W., furnished reports of occurrence on 9 days, or more than any other portion of the North Atlantic. In waters near the North American continent fog was met less frequently than usual in December, especially to northward of the 40th parallel. Near the Carolina coast to southwestward of Hatteras fog was observed on 3 days, and in the northwestern Gulf of Mexico on 2 days.

Between the 30th meridian and the coast of Europe, to northward of the 45th parallel, there was more fog, as a rule, than December normally brings, most of it occurring soon after the month began or in the period 24th to 29th. Some few occurrences were noted to southward of the 45th parallel; on the 24th one vessel met fog only a short distance northeast of Fayal, where it is very seldom seen.

OCEAN GALES AND STORMS, DECEMBER 1938

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began December	Time of lowest barometer December	Gale ended December	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Guadeloupe, Fr. M. S.	Havre	New York	47 39 N.	10 17 W.	1	11a, 1	1	29.65	WNW	WNW, 9		WNW, 9	W-WNW.
Montreal City, Br. S. S.	Halifax	Milford Haven	51 15 N.	10 35 W.	[3]30	Noon, 1	2	29.32	W	W, 9		W, 9	
Mormacsun, Am. S. S.	New York	Gothenburg	54 02 N.	36 40 W.	2	4a, 3	5	[2]28.75	SW	SSW, 9	WSW	SW, 10	SSW-SW.
Sarcoxie, Am. S. S.	Hull	Boston	49 13 N.	39 45 W.	2	4a, 3	4	29.36	WSW	W, 8	W	WSW, 10	WSW-W.
Braheholm, Swed. S. S.	Gothenburg	Portland, Maine.	53 53 N.	37 45 W.	3	10a, 3	4	[2]28.81		WSW, 9	W	WSW, 9	
Heddernheim, Ger. S. S.	Pentland Firth	Halifax	57 03 N.	27 55 W.	2	Noon, 3	5	28.95	SSE	SW, 11	W	WSW, 12	SSE-WSW.
Duchess of Atholl, Br. S. S.	Liverpool	do	55 14 N.	12 54 W.	4	9a, 4	7	29.15	W	W, 8	WNW	WNW, 10	S-W.
Bockenheim, Ger. S. S.	Iggesund	do	59 00 N.	9 24 W.	4	1p, 4	6	28.86	SSW	S, 10	WSW	S, 12	S-WSW.
Heddernheim, Ger. S. S.	Pentland Firth	do	56 48 N.	27 42 W.	6	2a, 6	7	29.15	W	W, 8	WNW	WNW, 10	W-WNW.
American Merchant Am. S. S.	London	New York	49 09 N.	26 45 W.	4	3p, 6	7	29.53	W	W, 8	NW	NW, 9	WSW-NW.
Steel Mariner, Am. S. S.	Gibraltar	do	42 00 N.	28 00 W.	6	Mdt, 6	7	30.11	WNW	NW, 8	NW	NW, 9	W-NW.
Heddernheim, Ger. S. S.	Pentland Firth	Halifax	53 54 N.	35 39 W.	9	Noon, 8	10	29.13	NW	WSW, 6	NNW	NW, 10	SSE-WSW.
Breedijk, Du. S. S.	Rotterdam	Norfolk	49 25 N.	35 08 W.	8	4p, 8	10	29.38	WSW	WSW, 9	NW	WNW, 10	WSW-W.
Steel Mariner, Am. S. S.	Gibraltar	New York	42 36 N.	34 50 W.	8	6p, 8	10	30.05	SW	SW, 9	NW	NW, 10	SW-WNW.
Black Eagle, Am. S. S.	Antwerp	do	[1]49 44 N.	29 05 W.	8	2p, 9	10	29.18	W	WNW, 10	NNW	WNW, 11	W-NW.
Rhode Island, Am. M. S.	New York	Port Arthur	35 15 N.	75 15 W.	9	7p, 9	10	29.62	WSW	SW, 5	WNW	W, 9	SE-SW-W.
Santa Rosa, Am. S. S.	do	Curacao	37 — N.	73 — W.	10	1a, 10	10	29.64	SW	SW, 7	WNW	W, 10	E-SW-W.
Arundo, Du. S. S.	Pepel	Rotterdam	[1]33 47 N.	13 14 W.	10	1a, 11	11	[2]29.27	SW	NW, 10	WSW	WNW, 12	SW-NW.
Emile Francqui, Belg. S. S.	Antwerp	New York	43 18 N.	52 12 W.	11	9a, 11	12	29.14	WSW	WSW, 8		WNW, 10	SW-W.
American Merchant, Am. S. S.	London	do	45 10 N.	52 00 W	11	Noon, 11	12	29.10	S	WSW, 9	NW	W, 10	SSW-WNW.
Breedijk, Du. S. S.	Rotterdam	Norfolk	45 04 N.	46 21 W.	11	Mdt, 11	12	29.16	WSW	WSW, 9	NW	NW, 10	WSW-NW.
Bockenheim, Ger. S. S.	Iggesund	Halifax	51 48 N.	41 30 W.	12	4a, 12	13	28.42	W	WNW, 10	W	WNW, 10	SW-WNW.
Black Eagle, Am. S. S.	Antwerp	New York	47 48 N.	42 00 W.	11	5a, 12	12	28.78	SSE	SW, 11	NW	SW, 12	SW-NW.
Adria, Ger. M. S.	Port Arthur	Brake	44 48 N.	28 48 W.	12	4p, 12	13	29.33		WNW, 11	NW	WNW, 11	
H. D. Collier, Am. S. S.	Hamburg	Cristobal	47 24 N.	19 30 W.	12	Mdt, 12	13	29.16	WSW	WSW, 7	WNW	W, 9	WSW-W.
Steel Mariner, Am. S. S.	Gibraltar	New York	40 57 N.	48 50 W.	13	3p, 13	14	29.62	SW	SW, 9	NW	W, 10	SW-W.
American Trader, Am. S. S.	New York	London	45 32 N.	40 40 W.	13	5a, 14	14	29.30	WNW	W, 11	NW	W, 11	WSW-W.
H. D. Collier, Am. S. S.	Hamburg	Cristobal	45 30 N.	25 06 W.	14	2p, 14	15	29.47	SW	SW, 10	WNW	WSW, 12	SW-WSW.
American Farmer, Am. S. S.	Havre	New York	49 18 N.	26 32 W.	14	6p, 14	15	28.80	SSE	W, 8	NW	NW, 11	SW-W.
Black Hawk, Am. S. S.	Rotterdam	do	50 43 N.	24 12 W.	14	11 p, 14	15	28.77	SSE	SW, 7	NW	NNW, 11	SW-N-NNW.
Cordelia, Br. M. S.	Port Arthur	Donges	28 50 N.	76 50 W.	15	4a, 16	16	29.70	ENE	NE, 8	NE	NE, 9	None.
Standard, Am. S. S.	Aruba	New York	28 30 N.	75 15 W.	16	4p, 16	16	29.63	ENE	NNE, 10	N	NNE, 10	NNE-N.
Mormactide, Am. S. S.	Copenhagen	do	53 41 N.	37 08 W.	16	11p, 16	18	28.84	WSW	NW, 9	NW	W, 11	SW-NW-WNW
Steel Worker, Am. S. S.	Avonmouth	Baltimore	51 00 N.	33 27 W.	16	1a, 17	18	29.13	S	WSW, 11	NW	W, 11	SW-WNW.
Black Hawk, Am. S. S.	Rotterdam	New York	48 45 N.	35 55 W.	16	2a, 17	17	29.42	SSW	W, 11	NW	W, 11	Steady.
Coamo, Am. S. S.	New York	San Juan	[1]29 00 N.	69 55 W.	16	4p, 17	17	29.63	ENE	SSE, 4	ESE	ESE, 10	SSE-W.
Good Gulf, Belg. M. S.	Antwerp	Port Arthur	46 00 N.	16 00 W.	17	8a, 19	19	29.21	SSE	NW, 8	NNE	NW, 10	
American Farmer, Am. S. S.	Havre	New York	41 18 N.	65 20 W.	19	1p, 20	20	29.36	ENE	NNE, 10	NNW	NNE, 10	ENE-N.
China Arrow, Am. S. S.	Cristobal	Providence	35 48 N.	73 30 W.	21	2p, 21	23	29.67	NW	NW, 7	N	NW, 9	W-NW.
Uganda, Br. S. S.	Huelva	Philadelphia	[1]33 58 N.	56 16 W.	22	3a, 23	23	29.50	SW	W, 7	NNW	W, 11	SW-WNW.
Trentbank, Br. S. S.	Gibraltar	St. John, N. B.	34 20 N.	40 09 W.	23	2a, 24	24	29.64	S	S, 12	S	S, 12	None.
Laurent Meeus, Belg. M. S.	Texas City	Holehaven	[1]33 52 N.	74 50 W.	24	8p, 24	26	29.79	WSW	NW, 9	N	NW, 9	WSW-NW.
Swiftscout, Am. S. S.	Marcus Hook	Houston	33 18 N.	77 40 W.	26	2a, 27	28	29.85	SE	SW, 9	NE	SSW, 10	S-SW.
Lady Somers, Br. S. S.	Bermuda	Boston	36 06 N.	66 18 W.	28	8a, 28	28	30.06		NW, 7		WNW, 9	SW-NW.
Laurent Meeus, Belg. M. S.	Texas City	Holehaven	[1]40 00 N.	58 19 W.	27	1p, 28	28	29.58	S	W, 9	W	SSW, 10	S-WNW.
NORTH PACIFIC OCEAN													
Aobasan Maru, Jap. M. S.	Yokohama	San Francisco	42 40 N.	156 50 E.	1	9a, 1	2	29.13	NW	NW, 5	NW	NW, 10	
Kaijo Maru, Jap. M. S.	Dairen	Port San Luis	42 34 N.	162 28 E.	1	4p, 1	2	28.70	WSW	W, 10	NW	W, 10	WSW-W.
Anglo-Peruvian, Br. S. S.	Comox, B. C.	Yokohama	48 39 N.	178 58 W.	1	8p, 1	3	28.70	E	NE, 9	W	NNE, 10	ENE-NNE.
San Clemente Maru, Jap. M. S.	Yokohama	San Francisco	[1]44 13 N.	164 20 E.	2	6p, 1	2	28.42	N	Var, 1	NNW	NW, 9	SW-Var-NW.
San Luis Maru, Jap. M. S.	do	do	45 08 N.	172 25 E.	1	6a, 2	2	28.52	E	SE, 1	NNW	NNW, 9	SE-S-W.
Swiftsure Bank Lightship, U. S.	On station		48 30 N.	125 00 W.	2	4p, 2	2	29.47		W, 9		W, 9	
Santa Maria, Am. S. S.	Vancouver, B. C.	Oleum, Calif.	44 54 N.	124 57 W.	2	8a, 2	2	29.56	SSW	SSW, 9	W	SSW, 9	SSW-W.
West Virginia, U. S. N.	Los Angeles	San Francisco	34 12 N.	119 48 W.	2	4p, 2	2	30.31		WNW, 8		WNW, 8	
Talthybius, Br. S. S.	Yokohama	Victoria, B. C.	49 59 N.	148 48 W.	2	10p, 2	2	29.01	SE	SSE, 7	SSE	SE, 8	SE-SSE.
Toho Maru, Jap. M. S.	San Francisco	Tokuyama	33 42 N.	160 06 W.	2	2a, 3	2	29.67	SSW	WSW, 5	SW	SSW, 8	SW-WNW.
Hopecrest, Br. M. S.	Cebu, P. I.	Los Angeles	37 37 N.	145 28 W.	3	1p, 3	3	29.81	S	S, 9	S	S, 9	S-NW.
San Luis Maru, Jap. M. S.	Yokohama	San Francisco	44 47 N.	173 47 W.	3	6p, 3	3	28.41	NNE	N, 9	NW	N, 10	NNE-NW.
Empress of Russia, Br. S. S.	Victoria, B. C.	Yokohama	[1]47 49 N.	166 35 E.	4	4a, 4	4	29.31	N	SW, 3	NW	NW, 9	S-SW-N.
Aobasan Maru, Jap. M. S.	Yokohama	San Francisco	43 18 N.	179 48 E.	4	Noon, 4	4	29.27		NW, 8		NW, 8	
Athelprincess, Br. M. S.	Estero, Calif.	Nagasaki	28 48 N.	172 36 W.	5		5	29.95	NW	SW, 6	NNW	NW, 8	S-WNW.
Toho Maru, Jap. M. S.	San Francisco	Tokuyama	33 32 N.	171 10 W.	4	2a, 4	5	29.61	W	SW, 7	SW	NW, 10	SSW-W.
Corneville, Nor. M. S.	Hong Kong	Los Angeles	31 35 N.	148 25 E.	5	8p, 5	5	29.79	SE	SSW, 9	SSW	SSW, 9	SSE-WSW.
Anglo-Peruvian, Br. S. S.	Comox, B. C.	Yokohama	47 06 N.	173 48 E.	4	Noon, 4	6	29.15		NW, 6	NW	NNW, 8	N-NW.
Empress of Russia, Br. S. S.	Victoria, B. C.	do	40 56 N.	150 37 E.	6	2a, 6	6	29.23	SE	SE, 9	NW	SE, 9	SE-W-NW.
Anglo-Peruvian, Br. S. S.	Comox, B. C.	do	44 55 N.	164 35 E.	6	Mdt, 6	9	29.26	SE	SW, 7	WNW	SE, 11	SE-W.
Empress of Asia, Br. S. S.	Yokohama	Victoria, B. C.	46 44 N.	169 01 E.	6	6a, 7	7	29.16	SSE	SE, 7	SE	SE, 9	SE-SW-W.
Tai Ping Yang, Nor. M. S.	do	Los Angeles	46 06 N.	175 36 W.	6	Mdt, 6	7	29.34		SE, 8		SE, 8	SE-W.
Columbian, Am. S. S.	Balboa	San Diego	16 00 N.	94 50 W.	7	6a, 7	7	29.87	WNW	NW, 8	N	NW, 8	WNW-N.
Washington, Am. S. S.	San Francisco	Balboa	15 55 N.	94 23 W.	9	4a, 10	10	29.95	NNE	NW, 5	NNW	NNW, 8	NNE-NW.
Anglo-Peruvian, Br. S. S.	Comox, B. C.	Yokohama	41 48 N.	157 08 E.	10	1p, 10	11	28.74	W	W, 10	NW	NW, 11	W-NW.
Toorak, Br. S. S.	Los Angeles	Onagawa	32 23 N.	173 27 E.	10	7a, 11	12	29.43	S	SW, 9	W	SW, 9	S-W.
Silvermaple, Br. M. S.	Manila	Portland, Oreg.	30 49 N.	161 05 E.	10		11		S		WNW	WNW, 8	S-WNW.
Matsonia, Am. S. S.	Honolulu	Los Angeles	33 00 N.	124 22 W.	13	2p, 13	13	29.59	SE	SE, 8	SE	SE, 8	
Mauna Ala, Am. S. S.	Mahukona, T. H.	San Francisco	32 42 N.	136 00 W.	13	6a, 13	13	29.77	N	N, 8	N	N, 8	
Do	do	do	[1]34 12 N.	132 33 W.	14	6a, 14	14	29.62	N	N, 6	N	N, 8	

[1] Position approximate. [2] Barometer uncorrected. [3] November.

OCEAN GALES AND STORMS, DECEMBER 1938—Continued

Vessel	Voyage		Position at time of lowest barometer		Gale began December	Time of lowest barometer December	Gale ended December	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
			° ′	° ′				Inches					
Toorak, Br. S. S.	Los Angeles	Onagawa	33 51 N.	159 19 E.	14	11p, 14	14	29.40	S	SW, 10	W	SW, 10	SW-W.
Tuyama Maru, Jap. S. S.	Yokohama	San Francisco	41 23 N.	171 00 W.	14	Mdt, 14	15	[2]29.30	S	S, 10	W	SSW, 10	S-W.
Zuiyo Maru, Jap. S. S.	Yura	Los Angeles	[1]41 49 N.	155 46 E.	14	4a, 16	16	29.56	NW	W, 7	NW	W, 9	W-NW.
Dickenson, Am. S. S.	Fanning Island	Honolulu	5 10 N.	159 17 W.	15	4a, 15	18	29.74	NE	E, 2	NE	NE, 8	None.
Silvermaple, Br. M. S.	Manila	Portland, Oreg.	41 00 N.	167 00 W.	14	6a, 15	15	29.39	SSW	SSW, 9	WNW	SSW, 9	S-W.
Kongo Maru, Jap. M. S.	Yokohama	Los Angeles	46 00 N.	174 39 E.	15	Noon, 15	15	28.64	WNW	WNW, 7	W	W, 8	WSW-WNW.
Silvermaple, Br. M. S.	Manila	Portland, Oreg.	44 48 N.	152 18 W.	16	2p, 17	17	29.84	S	S, 9	WNW	S, 9	SSE-SSW.
Pres. Cleveland, Am. S. S.	San Francisco	Honolulu	[1]36 33 N.	127 04 W.	18	2a, 18	18	29.78	N	NE, 7	N	N, 8	NE-N.
Ewa, Am. S. S.	Honolulu	Los Angeles	31 06 N.	131 30 W.	18	3p, 18	20	29.98	NNW	NNW, 9	NNW	NNW, 9	
Nagara, Maru, Jap. M. S.	Yokohama	do	46 12 N.	178 18 W.	18	Noon, 18	19	29.21	SW	WSW, 7	SW	W, 8	SW-WSW.
Zuiyo Maru, Jap. S. S.	Yura	do	42 26 N.	170 08 E.	18	5p, 18	19	29.25	WSW	SE, 5	W	WSW, 9	SE-WSW.
Arimasan Maru, Jap. M. S.	Yokohama	San Francisco	43 19 N.	160 53 E.	18	Mdt, 18	19	29.27	ESE	SW, 9	NW	W, 9	ESE-SW-W.
Empress of Japan, Br. S. S.	Honolulu	Yokohama	31 02 N.	151 48 E.	22	10p, 22	23	29.68	S	WSW, 9	NW	WSW, 9	S-NW.
Olympia Maru, Jap. M. S.	Dairen	Los Angeles	39 53 N.	174 20 E.	22	5p, 23	24	[2]29.38	ENE	SSW, 10	W	S, 10	SSE-WSW.
Hikawa Maru, Jap. M. S.	Yokohama	Vancouver	[1]46 45 N.	167 16 E.	23	6p, 23	25	28.03	ESE	SE, 8	W	W, 9	SE-SW.
Empress of Japan, Br. S. S.	Honolulu	Yokohama	[1]34 43 N.	140 16 E.	23	5a, 24	24	29.34	SE	SW, 6	SW	SSE, 9	SE-SW.
Pres. Coolidge, Am. S. S.	Yokohama	Honolulu	34 53 N.	142 56 E.	24	Noon, 24	25	29.40	SW	SW, 9	NW	WSW, 9	SW-WSW.
Tyndareus, Br. S. S.	do	Victoria, B. C.	46 48 N.	168 06 E.	29	11p, 29	30	29.36	W	W, 7		W, 8	
San Marcos, Am. S. S.	Balboa	San Diego	15 17 N.	93 12 W.	30	Noon, 30	30	29.88	WNW	NW, 3	NNW	NW, 8	NW-WNW.
Maunalei, Am. S. S.	Honolulu	San Francisco	26 18 N.	149 18 W.	31	2p, 30	31	29.93	WNW	W, 3	WNW	WNW, 8	
Mauna Ala, Am. S. S.	Seattle	Honolulu	48 06 N.	125 12 W.	31	Mdt, 31	[4]1	29.31	SSE	SSE, 10	SW	SSE, 10	SSE-SE-S.

[1] Position approximate. [2] Barometer uncorrected. [4] January.

NORTH PACIFIC OCEAN, DECEMBER 1938

By Willis E. Hurd

Atmospheric pressure.—Pressures were almost continuously low in the Aleutian region in December 1938, except on the 23d to 25th, when a high-pressure area moved eastward across the islands, giving barometer readings above 30 inches, first at Dutch Harbor, then at Kodiak. At Dutch Harbor and St. Paul the average pressures were 29.21 and 29.27, respectively, or in both instances more than 0.3 inch below the normals of the month. The average pressure rose sharply southward toward Midway Island, where the mean reading of the month, 30.20 inches, was 0.19 inch above the normal. Barometer readings at this station were as continuously high as they were low at the Aleutian stations.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, December 1938, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	Inch	Inches		Inches	
Point Barrow	29.88	−0.15	30.74	25	28.98	17
Dutch Harbor	29.21	−.35	30.10	23	28.10	15
St. Paul	29.27	−.31	30.18	23	28.48	12
Kodiak	29.39	−.17	30.28	25	28.74	16
Juneau	29.80	+.01	30.56	25	29.17	31
Tatoosh Island	30.08	+.12	30.46	11	29.08	2
San Francisco	30.11	−.01	30.47	2	29.71	15
Mazatlan	29.94	+.01	30.00	10	29.88	9, 26
Honolulu	30.02	+.01	30.17	17	29.79	28
Midway Island	30.20	+.19	30.45	6	30.09	1, 3, 4
Guam	29.85	−.02	30.09	11	29.77	4, 26
Manila	29.82	−.04	29.92	31	29.65	7
Hong Kong						
Naha	30.10	+.12	30.27	30	29.71	20
Titijima	30.06	+.06	30.24	31	29.77	21
Petropavlosk	29.30	−.23	30.09	5	28.70	28

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

On the average, pressures exceeded 30 inches along the coast of the United States and thence westward to southwestward to beyond Midway Island. Average pressures were also high to the eastward of the China coast, including the Nansei and Ogasawara Islands, 30.10 to 30.06 inches.

Pressures below 29 inches occurred in higher latitudes of the Pacific, as shown on our charts, on 16 days in December, thus attesting to the depth of the several cyclones. The lowest corrected pressure reported by a ship was 28.03, read on the Japanese motorship *Hikawa Maru*, near 47° N., 167° E., on the 23d. Nearly as low pressures occurred among the Aleutians on the 11th and 15th.

Extratropical cyclones and gales.—For the North Pacific as a whole, December was the stormiest month to date of the present winter—much stormier than November, and having more sustained storminess than October, although October had a considerably greater number of local gales of intensity higher than force 10. In December, as indicated by ships' reports now at hand, gales were experienced of force as high as 11 on only 2 days, the 6th and the 10th, to the eastward of the Kuril Islands. However, stormy regions were of great width, as well as depth, on several days, and winds of whole gale force (10) were of frequent occurrence, particularly over that part of the ocean lying west of longitude 170° W., and north of latitude 30°.

Between about longitudes 130° and 160° W., gales were few and scattered, being thus far reported on only 7 days, and for the most part not exceeding force 8. The comparative freedom from severely stormy weather in this part of the ocean was largely due to the considerable prevalence there of anticyclones.

Between longitude 130° W. and the coast of the United States gales were of greater importance. On the 2d westerly winds of force 9 occurred along the Washington and Oregon coasts. The maximum wind velocity of the month at Tatoosh Island was at the rate of 67 miles an hour from the southwest, registered on the 2d at the Weather Bureau office. On the 31st, during the prevalence of a cyclone in extreme northeastern waters, the American Steamship *Mauna Ala*, while off Cape Flattery, had a southeasterly gale of force 10. Off central and southern California, gales of force 8 were experienced by ships

on the 13th, 14th, and 18th, in connection with a cyclone that developed to the northeastward of the Hawaiian Islands on the 11th and, slowly moving eastward, entered the California coast on the 19th.

The greater part of the strong extratropical cyclonic activity of the month occurred in connection with low pressure systems east of Japan and those peculiar to the Aleutian LOW. Many of these were of enormous extent and on several days caused fresh to strong and even whole gales as far southward as the 30th parallel, as well as over considerable areas in higher latitudes in both west and east, but principally in east, longitudes. An inspection of the accompanying table, *Ocean Gales and Storms*, will indicate the intensity and distribution of the stormy conditions encountered by North Pacific ships.

On the 1st to 3d of the month fresh gales were experienced within the area 30° to 50° N., 145° to 160° W., and fresh to whole gales along the central and western parts of the northern steamer routes. On the Japanese motorship *San Clemente Maru* pressure fell to 28.42, with a northwest wind of force 9, in the vicinity of 44° N., 164° E., on the 2d. Near midnight of the 1st, in about 49° N., 179° W., the British steamship *Anglo-Peruvian* had a north-northeast gale of force 10, lowest barometer 28.70. This ship had a rough passage thence westward toward Yokohama, since on the 6th, near 45° N., 165° E., she encountered a northeast gale of force 11, and on the 10th, near 42° N., 157° E., she met a wind of similar force, from the northwest, barometer 28.74.

December 10 and 11 were particularly stormy days over considerable regions in east longitudes—of force 10 to 11 in northern waters, and of force 8 to 9 between the 30th and 40th parallels. On the central Aleutians pressure was very low, with a minimum of 28.10 reported on the 11th.

On the 14th to 16th widespread gales, some rising to force 10, were reported within the region between 160° W. and 155° E. The strongest gales of the period occurred on the 14th near 34° N., 159° E., and 41° N., 171° W.

On the 23d a storm developed over Japan and moved rapidly northeastward, on the 24th causing strong gales outside of the port of Yokohama. On the 23d a storm central near 47° N., 167° E., where the pressure was reported as 28.03 inches, caused strong gales in the vicinity, and strong to whole gales (forces 9–10) as far eastward as 170° W.

There was a considerable general abatement in storminess during the last week in December.

Typhoons and depressions over the Far East.—One typhoon of hurricane strength, that of December 3–10, occurred in tropical waters of the Far East and was destructive in the central Philippines on the 8th. An account of this storm and of three depressions, prepared by the Rev. Bernard F. Doucette, S. J., Weather Bureau, Manila, P. I., is subjoined.

Tehuantepecers.—The following northerly gales in the Gulf of Tehuantepec, due to strong anticyclones pressing southward into the Gulf of Mexico, were reported: Of force 8 on the 7th, 9th, 10th, 28th, and 30th.

Intensified trade wind.—The American S. S. *Dickenson*, Fanning Island toward Honolulu, reported a northeast gale of force 8 in latitude 5°10′ N., longitude 159°17′ W.

Fog.—Fog occurred on three or four scattered dates on the open North Pacific in west longitudes during December, but it was mostly confined, so far as reports indicate, to United States coastal waters. There were 2 days with fog off the Washington and Oregon coasts; 8 days with fog off the California coast; and 3, off Lower California. Fog was reported on December 31 a short distance southwest of Costa Rica.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST, DECEMBER 1938

BERNARD F. DOUCETTE, S. J.

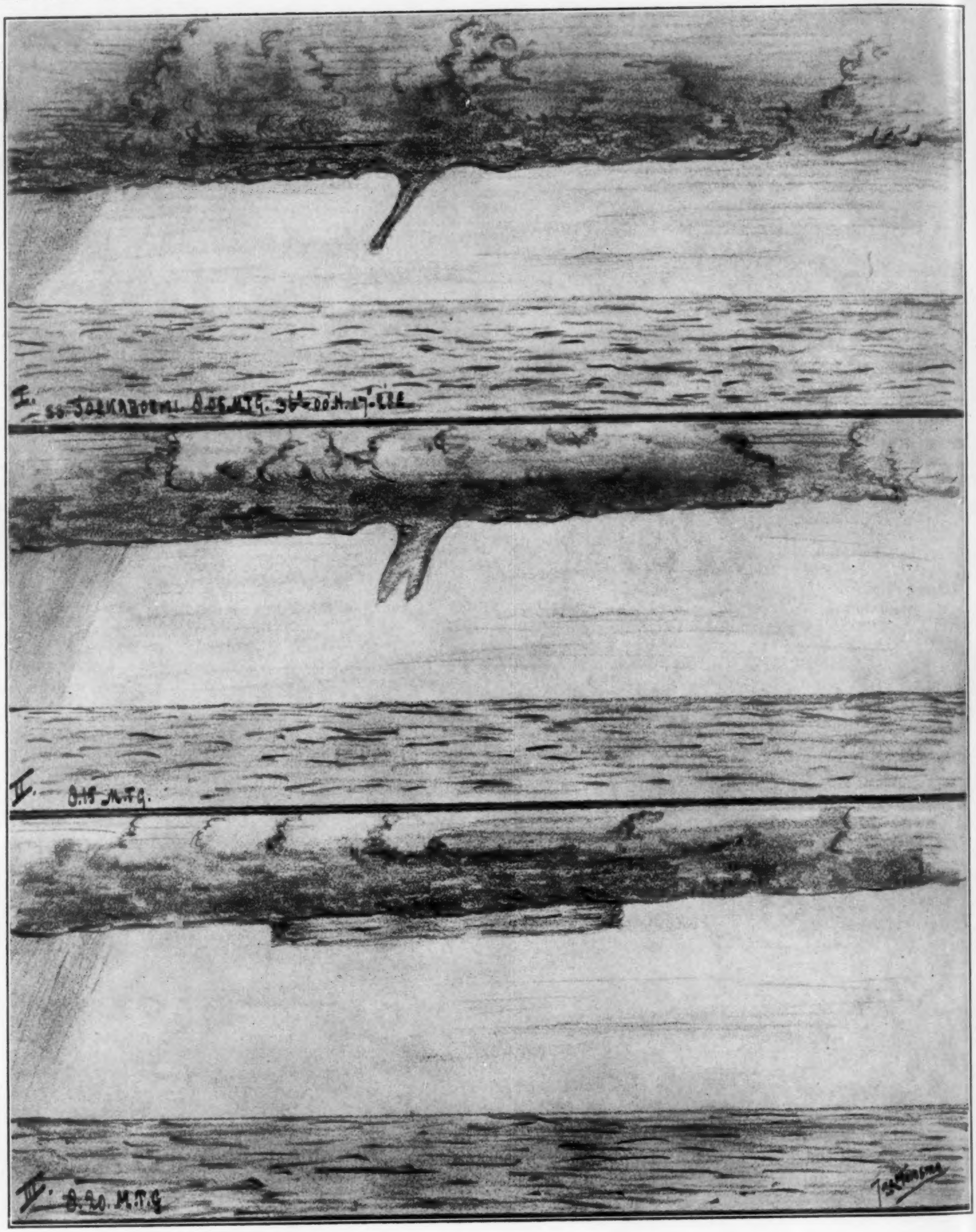
[Weather Bureau, Manila, P. I.]

Depression, December 1–5, 1938.—A depression, apparently of minor importance, formed over the western Caroline Islands, moved west, then west-northwest, finally inclining to the west-southwest as the center moved across the Visayan Islands to the Sulu Sea where it disappeared.

Typhoon, December 3–10, 1938.—This storm appeared about 300 miles south of Guam on December 3, apparently well developed, after it had formed over the regions adjacent to the eastern Caroline Islands. On December 4 there was no doubt that the storm was of typhoon intensity and was moving in a west-northwesterly direction; it later inclined to the west, thus approaching northern Samar. As it came near San Bernardino Strait, it again took a course to the west-northwest, passing a short distance north of Laoang during the late evening hours of December 7. The typhoon crossed the Archipelago December 8, passing about 100 miles south of Manila, moving west-northwest, at approximately 2 p. m. The center moved across the northern part of Mindoro Island into the China Sea, where it weakened as it rapidly progressed toward Indochina. On December 10, it entered the continent, where it quickly disappeared, apparently of weak intensity.

Over the Philippines, this was the worst typhoon of the year. On December 14, the final total of deaths was published, the number being 305. The greatest havoc occurred over northern Samar and the extreme southern portions of Luzon. The lowest barometric readings occurred at Legaspi, Sorsogon, and Laoang. At Laoang, Samar Province, 723.84 mm. (28.50 in.) was recorded December 7, at 9:30 p. m. Sorsogon, Sorsogon Province, had its minimum of 726.90 mm. (28.82 in.) at 2 a. m. December 8. Legaspi, Albay Province, reported a value of 732.71 mm. (28.85 in.) as its minimum, at 2:20 a. m. December 8. The storm center passed very close to and south of Sorsogon. Winds of force 12 were experienced at these three stations as well as at a few neighboring cities. Later on in the day, Boac, Marinduque Province, had a minimum reading of 740.76 mm. (29.16 in.) when the center was within 50 miles south of the station (10 a. m. December 8) indicating that the storm was weakening. The steamship *Admiral Halstead* was anchored in Sorsogon Bay while the typhoon approached and passed over the locality. Two radiograms were sent to the observatory, the messages reading as follows: "15:45 G. M. T. Dec. 7, lat. 12°56′ long. 123°55′ 11:30 p. m.; wind north-by-west force 10; barometer 29.20; steady heavy rain". "December 8, 1 a. m., at Sorsogon Bay, wind north-northeast, force 12, barometer 28.50, 2 a. m., wind light southeast; barometer commenced rising." The steamship *Baron Stranraer* sent the following message during the forenoon hours of December 8: "Dec. 8, lat. 13°00′ N., long. 122°20′ E., typhoon, severe center, passed over vessel 7 a. m. local time; lowest barometer 28.50; present weather: wind south, 11, decreasing; barometer 29, rising; severe squall."

As the series of extra observations ordered as the typhoon approached the archipelago arrived at the observatory, it seemed that a secondary disturbance of consider-


II. 8.15 M.T.G.
III. 8.20 M.T.G.

able intensity was in existence over southern Samar, the observations from Borongan giving this impression. Future study of more complete observations is necessary to confirm this idea.

The severe intensity of this typhoon could be understood from a 24-hour pressure fall of 4 mm. (0.1575 in.) at Yap, December 3 to 4, together with east winds of velocities between 50 and 80 kilometers per hour over Guam, as the storm center passed south of the island. These high velocities persisted until the typhoon was about 500 miles away from San Bernardino Strait. Aerological stations over the Philippines did not have winds of any strength until December 8, when the storm center was over the Archipelago. It must be remembered that the depression over the Sulu Sea influenced the upper winds until December 5. But velocities over 55 kilometers per hour were not reported until December 8, the strongest values being at Manila and Dagupan, the latter station reporting values up to 100 kilometers per hour, directions being from east and southeast quadrants.

Depression, December 12–18, 1938.—A low pressure area appeared over the western Caroline Islands, moved west-northwest and west toward the Philippine Archipelago, manifesting the strength of a depression after December 14. The center passed over the regions neighboring Surigao Strait, then inclined somewhat to the west-southwest and disappeared over the Sulu Sea. The upper winds reported while this disturbance was in existence indicated that the trade wind alone was acting. The weather situation was such that little, if any, air was coming from the northern regions, while the few reports received from Malaya and Java stations showed that the Southwest Monsoon current was weak. On the other hand, Guam had east and east-southeast winds with velocities up to 50 kilometers per hour and higher during these days.

Depression, December 21–22, 1938.—An extended, persistent trough of low pressure over the China Sea, Formosa and the regions adjacent to the Nansei (Loochoo) Islands finally developed into a maritime northern depression of some strength on December 21. This center appeared rather close to and east of the Nansei Islands, and then moved rapidly northeast and east beyond the regions of observation.

WATERSPOUT OF OCTOBER 29, 1938, IN THE MEDITERRANEAN SEA

The annexed illustrations of a waterspout were reproduced from sketches sent to the Marine Division by Third Officer J. Meinsma of the Dutch Steamship *Soekaboemi*, Capt. H. D. Braspot, while in the Mediterranean Sea on October 29, 1938. Although the waterspout appears to have been imperfectly developed, as its trunk did not span the entire distance between the cloud and the sea, Mr. Meinsma's drawings show three phases of the spout's existence finely delineated. The ship at time of the first observation was near 36° north latitude, 17½° east longitude. The time was 08:05 M. T. G. The subsequent drawings show the phenomenon at 08:15 and 08:20, at which latter time what remained of the trunk is shown as a wide flattened projection extending only a short distance from the cloud base. The height of the cloud base according to Mr. Meinsma, "was about 1,200 feet above the horizon. At the left side it was raining."

The accompanying weather was: "Cloudy, with sunshine; barometer 759.6 (corrected); air temperature 20.2° C.; water temperature 20.0° C.; wind west-northwest, force 3; sea and swell, west-northwest, 2."—*W. E. Hurd.*

SEA-SURFACE TEMPERATURE SUMMARY FOR WATERS OFF THE COAST OF NORTHWESTERN UNITED STATES AND SOUTHERN VANCOUVER, 1912–29

By GILES SLOCUM

The area embraced in this summary comprises, as shown on figure 1, one 5°-square, from 40° to 45° N., and from 125° to 130° W., and parts of two 5°-squares along the coast between 40° and 50° N.

Normal temperatures for each month and for the year are shown in table 1 for each of the areas. The annual range of surface temperature here is rather small for the latitude, and is in marked contrast with the range[1] on

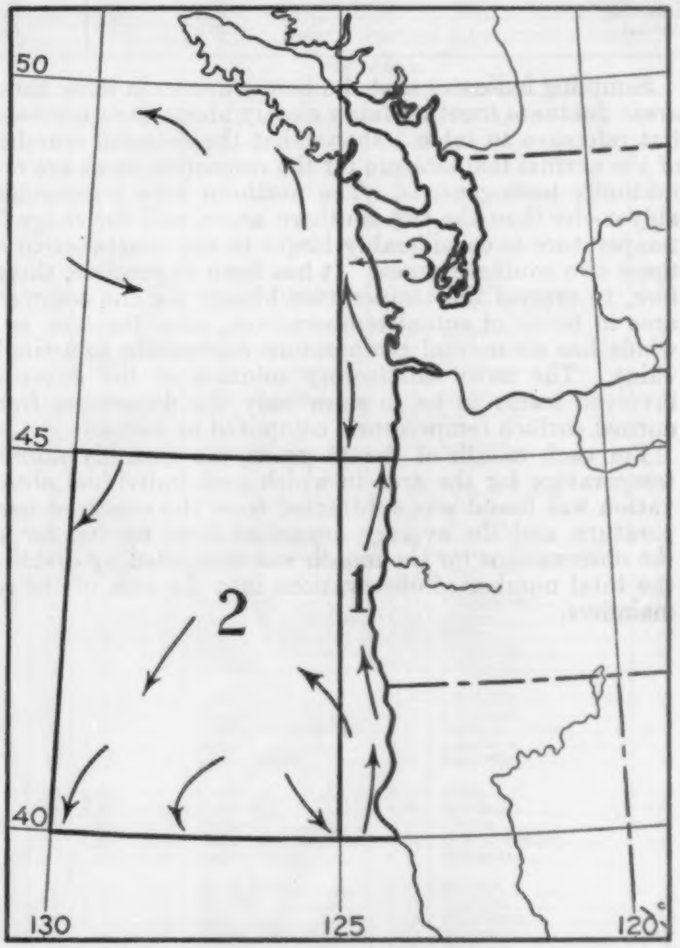


FIG. 1.—Chart identifying area numbers listed in table 1. Arrows show set of surface water currents.

the east coast of the United States at the same distance north, where the summer to winter temperature drop is in excess of 20° F., and close to the coast exceeds 30°.

Observations are not numerous in these three areas, as can be seen by reference to table 2. Compilation of a satisfactory temperature history for each area is therefore impossible because the number of observations per month is insufficient to indicate significantly the uniformly small temperature departures which obtain. The three areas have been combined in this paper to provide what is even then a practically irreducible minimum of observations for each month of the period covered, 1912 to 1929, inclusive.

[1] Slocum, Giles, The Normal Temperature Distribution of the Surface Water of the Western North Atlantic Ocean, MONTHLY WEATHER REVIEW, Vol. 66, pp. 39–43.

TABLE 1.—*Normal monthly temperatures*

[Areas numbered as in the illustration]

Month	Temperatures		
	Area No. 1	Area No. 2	Area No. 3
	°F.	°F.	°F.
January	50.4	50.5	46.2
February	50.2	50.5	45.8
March	49.2	49.7	46.0
April	49.8	50.6	47.9
May	51.7	52.7	50.7
June	53.2	55.3	53.3
July	54.3	58.4	56.2
August	55.0	60.7	56.0
September	55.7	61.0	55.1
October	54.3	57.9	52.8
November	52.7	55.8	50.3
December	51.3	53.4	47.9
Annual	52.3	54.7	50.7

Sampling indicates that the temperatures in these three areas fluctuate together fairly closely about their normals, but reference to table 1 shows that the seasonal marches of the normal temperature for the respective areas are not mutually homogeneous. The northern area is considerably cooler than the two southern areas, and the range in temperature is considerably larger in the coastal strip of these two southern areas. It has been impossible, therefore, to express the temperature history for the complete area in terms of actual temperatures, since the area as a whole has no normal temperature expressible as a single value. The most satisfactory solution of the dilemma involved seems to be to show only the departures from normal surface temperature, computed as follows:

For each month of the 18 years, the monthly normal temperature for the area in which each individual observation was found was subtracted from the observed temperature, and the average departure from normal for all the observations for the month was computed by dividing the total number of observations into the sum of the remainders.

Normal temperatures used are 20-year values, including 1930 and 1931 observations. The small number of observations for these 2 years made it impossible to compile satisfactory monthly temperature histories later than 1929. Temperature departures for 1930 and 1931 were generally above normal, except for possibly the final third of 1931. The computed departures for 1930, based on 78 observations combined for the three areas, was +0.8°; and for 1931, based on 22 observations, was + 0.5°.

This is the thirteenth of a series of sea-surface temperature history tabulations for small oceanic areas near to the North American continent, but is the first covering west coast data. The first of the series of compilations appeared in the November 1934 issue of the MONTHLY WEATHER REVIEW, and the last previous tabulation appeared in the October 1938 issue.

TABLE 2.—*Monthly and annual mean sea-surface temperature departures from normal off the northwestern coasts of the United States, 1912 to 1929, inclusive*

Year	Total number of observations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1912	260	−1.8	−0.1	−0.2	−1.5	+1.4	+0.7	+1.3	+2.4	+0.3	−2.1	−0.8	−1.9	−0.2
1913	340	−0.9	−3.7	−1.8	−2.0	−1.2	+2.6	+2.1	+0.5	+0.2	−0.7	−0.6	−0.4	−0.5
1914	161	−0.1	−2.2	+1.9	+1.4	+0.2	+0.6	−1.4	−0.7	−1.0	+1.5	+1.6	+1.4	+0.3
1915	272	+0.6	+3.0	−0.3	+2.1	−0.1	−0.1	−1.2	+0.8	+1.3	−0.3	−0.2	+0.1	+0.5
1916	230	−2.9	−0.8	+0.7	+1.0	−0.5	−1.0	−0.8	+2.0	+0.1	−2.6	−3.1	−2.5	−0.9
1917	307	−1.7	−1.4	−1.6	−1.8	−0.9	−0.6	−1.3	−1.8	+0.7	−1.7	+1.0	+2.7	−0.7
1918	286	+2.6	+1.2	−0.1	+0.1	−0.7	−2.1	−2.5	+0.5	−1.0	0.0	+0.5	−0.2	−0.1
1919	233	+0.2	+0.5	+0.2	+0.9	−0.4	−3.3	−3.5	−1.4	−0.3	−1.9	−1.7	−2.0	−1.1
1920	324	−1.8	−0.3	−0.1	−1.3	−1.7	−1.0	+1.3	−2.6	−1.8	+0.6	−0.4	+0.3	−0.7
1921	218	−0.3	+0.3	−0.6	0.0	−1.2	+1.7	−3.9	−2.5	+0.5	+0.8	+1.4	−0.6	−0.4
1922	187	−0.8	−3.4	−0.7	−2.7	−2.0	+1.2	−1.5	−0.2	−0.1	+3.2	−2.1	−0.2	−0.8
1923	240	−0.1	−0.8	−1.7	−1.7	+0.3	+0.2	+1.9	+2.6	+2.4	+2.2	+1.9	+0.2	+0.6
1924	375	−0.3	+1.6	+0.2	+0.1	−0.4	+0.2	−1.1	+0.6	−2.0	−0.1	+0.4	−1.0	−0.2
1925	266	−0.6	−0.5	+2.7	+0.8	+0.6	+0.7	+1.2	+0.5	+1.2	+0.1	−2.4	+2.0	+0.5
1926	330	+2.8	+3.2	+3.6	+4.2	+4.6	+1.9	+1.2	+2.5	+2.5	+2.8	+2.2	+1.5	+2.8
1927	217	+2.3	+0.5	+1.5	+0.4	+0.2	−1.4	+0.9	+0.6	+1.3	+1.4	+1.8	−1.2	+0.7
1928	215	+1.2	+1.1	+0.2	−0.2	+1.4	+1.9	+1.0	+1.5	−2.0	−1.1	+1.0	+2.5	+0.7
1929	257	+0.4	−1.1	−0.1	−0.1	+2.2	+1.7	+1.1	−0.7	−1.1	−0.5	+0.3	+0.6	+0.2

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, December 1938*

[For description of tables and charts, see REVIEW, January, p. 29]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	47.8	+0.3	Livingston	79	1	Florence	14	28	2.64	−2.77	Vernon	5.30	Newton	1.21
Arizona	45.4	+2.8	Casa Grande Ruins.	87	9	Fort Valley	−1	29	2.18	+.94	Pinal Ranch	5.63	Leupp	.06
Arkansas	43.7	+1.0	Arkadelphia	82	[1]1	White Rock	6	27	2.93	−1.33	Lutherville	6.11	Fayetteville	.66
California	47.4	+1.8	Lamesa	100	8	Sierraville	−2	26	2.78	−.94	Mount Wilson	15.23	Sierraville	.06
Colorado	27.3	+1.7	2 stations	72	[1]5	Fraser	−31	14	.89	−.02	Aspen	3.44	Holly	.05
Florida	58.6	−1.1	do	88	[1]5	Vernon	22	1	1.38	−1.35	Compass Lake	5.46	Everglades	T
Georgia	47.1	−.6	Waycross	83	4	Blairsville	8	28	2.68	−1.56	Eastman	4.65	Cummings	.92
Idaho	28.8	+2.6	Milner Dam	64	8	Island Park Dam	−30	26	1.46	−.58	Roland	7.04	Arco	.00
Illinois	31.9	+1.0	2 stations	68	[1]1	2 stations	−6	[1]30	1.65	−.49	Griggsville	2.90	2 stations	.54
Indiana	33.0	+.8	do	67	[1]2	5 stations	0	[1]28	1.70	−1.13	Crawfordsville	3.21	Richmond	1.01
Iowa	26.3	+2.3	Keokuk	56	2	Cresco	−15	30	.71	−.47	Grinnell	1.63	Guthrie Center	.13
Kansas	36.2	+3.2	Elkhart	78	9	Dresden	−10	27	.20	−.64	Columbus	1.22	5 stations	.00
Kentucky	37.9	+.2	2 stations	67	[1]2	Mammoth Cave	3	28	1.85	−2.05	Pippapass	3.62	Oneonta	1.03
Louisiana	52.3	−.1	Schriever	82	23	2 stations	19	28	3.53	−1.79	Belle Chasse	7.24	Port Eads	1.06
Maryland-Delaware	36.2	+.8	Snow Hill, Md.	68	[1]5	Grantsville, Md.	−1	29	2.80	−.52	Cambridge, Md.	4.61	Mount Savage Summit, Md.	1.08
Michigan	27.1	+1.4	St. Joseph	58	5	Sidnaw	−29	30	2.17	+.12	Deer Park (near)	4.53	Watersmeet	.88
Minnesota	17.4	+1.9	Canby	54	3	Warroad	−42	29	.62	−.16	Pigeon River Bridge	1.92	Angus	.16
Mississippi	47.5	−.7	Fruitland Park	80	12	3 stations	16	28	3.50	−1.79	Bay St. Louis	5.96	Fulton	1.50
Missouri	35.9	+1.8	Doniphan	72	11	do	2	[1]27	1.83	−.33	Monroe City	3.70	Maryville	.27
Montana	26.4	+3.4	Lewistown	65	8	Outlook	−40	29	.56	−.32	Summit	5.96	8 stations	T
Nebraska	30.2	+3.3	3 stations	68	[1]1	Nenzel (near)	−17	27	.18	−.50	Potter	1.04	4 stations	.00
Nevada	35.2	+4.2	Beatty	78	9	Beowawe	−6	13	.42	−.57	Sharp	1.78	5 stations	.00
New England	28.6	+2.1	Plymouth, Mass.	61	6	Fort Kent, Maine	−21	31	3.88	+.54	Pinkham Notch, N.H.	6.84	Eastport, Maine	2.53
New Jersey	34.8	+1.1	Hammonton	67	[1]4	Layton	1	2	2.80	−.85	Sussex	5.11	Lakewood	1.16
New Mexico	36.0	+2.0	2 stations	80	[1]8	Eagle Nest	−27	24	.76	+.07	Eick's Ranch	2.87	3 stations	.00
New York	28.9	+2.1	Poughkeepsie	63	4	Indian Lake	−19	29	2.90	−.01	2 stations	5.14	Avon	.69
North Carolina	42.0	−.5	Kinston	75	12	Mount Mitchell	1	28	3.21	−.62	Hatteras	8.98	Marshall	.92
North Dakota	18.2	+5.5	Hettinger	55	25	Willow City	−41	29	.32	−.17	Towner	.91	Linton	.03
Ohio	32.9	+1.3	2 stations	63	4	2 stations	1	28	1.37	−1.38	Napoleon	2.92	Mount Vernon	.69
Oklahoma	42.1	+2.3	Frederick	81	10	Oakwood	6	27	.62	−1.05	Smithville	3.36	Mangum	T
Oregon	35.1	+1.7	Tiller	79	[1]9	Fall River	−14	13	2.48	−1.32	McNamers	13.19	Paisley	T
Pennsylvania	32.2	+.9	Hanover	64	5	2 stations	−5	29	2.56	−.54	Freeland	5.49	Clairton	.82
South Carolina	46.1	−.6	2 stations	80	4	Longcreek (near)	13	28	2.75	−.85	Laurens	5.22	Charleston	1.14
South Dakota	25.7	+4.1	Longvalley	65	15	Britton	−24	29	.26	−.28	Harveys Ranch	2.03	McIntosh	.00
Tennessee	40.4	−.3	Moscow	73	11	Crossville	8	28	2.53	−2.02	Milan	3.78	Franklin	1.16
Texas	50.3	+1.4	Port Isabel	89	18	2 stations	5	27	1.72	−.56	Corpus Christi	6.44	6 stations	.00
Utah	30.7	+4.0	3 stations	67	[1]6	Woodruff	−13	23	.97	−.13	Great Basin Experiment Station.	3.11	Loa	.08
Virginia	38.0	.0	5 stations	69	[1]5	Mountain Lake	2	28	2.83	−.25	Big Meadows	5.68	Wytheville	.93
Washington	34.3	+1.6	2 stations	67	[1]2	Laurier	−11	27	4.54	−.55	Wishkah Headworks	24.30	Sunnyside	.29
West Virginia	34.7	+.1	Hinton	69	4	Bayard	−5	29	1.81	−1.50	Martinsburg	4.58	Shinnston	.60
Wisconsin	21.1	+.7	Sturgeon Bay	53	10	P. K. Reservoir	−39	30	1.28	−.05	Laona	3.01	Spooner	.42
Wyoming	24.0	+2.2	Lagrange	62	9	West Yellowstone	−36	12	.68	−.07	Snake River	3.80	Eden	.00
Alaska (November)	19.5	+5.5	Tree Point	59	[1]23	Alakaket	−37	15	3.56	+.85	Little Port Walter	28.86	Ophir	.25
Hawaii	71.3	+1.1	Napoopoo	90	6	Kanalohuluhulu	40	28	7.15	−1.74	Gilhonua	37.40	3 stations	.00
Puerto Rico	74.4	+.3	Dos Bocas	93	19	Guineo Reservoir	51	1	5.16	+.64	La Mina (El Yanque)	16.09	Juana Diaz	.38

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau stations, December 1938*

[Compiled by Annie E. Small by official authority U. S. Weather Bureau]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							30.8	+2.3										76	3.80	+0.4										6.5		
Eastport	75	67	85	29.91	29.99	+0.01	29.6	+3.3	56	6	37	3	29	22	32	28	24	80	2.53	-1.2	16	13.4	nw.	44	s.	6	6	8	17	6.8	7.8	2.6
Greenville, Me.	1,069	4	41	28.89	30.03		20.2	+1.6	51	6	29	-21	31	12	40	19	17		4.77	+1.6			nw.									
Portland, Me.	103	82	117	29.91	30.04	+.01	31.0	+3.4	57	4	37	8	29	25	33	27	22	71	4.29	+.3	18	9.1	n.	32	s.	4	6	12	13	5.6	2.3	.1
Concord	289	54	72	29.71	30.04	-.02	28.5	+1.7	55	4	36	0	3	21	29				4.04	+.9	15	6.0	n.	24	sw.	26	7	4	20	7.3	6.8	1.6
Burlington	403	11	48	29.57	30.04	-.01	26.0	+1.6	49	4	32	1	29	20	27	24	20	78	3.64	+1.8	14	10.9	s.	35	s.	3	5	4	22	7.6	7.6	1.2
Northfield	876	12	60	29.06	30.05	.00	23.7	+3.3	50	4	32	-10	29	16	33	21	18	84	3.78	+1.3	19	7.3	sw.	28	s.	4	5	6	20	7.4	7.6	4.7
Boston [1]	29	33	62	30.01	30.04	-.01	34.0	+1.5	57	4	40	13	2	28	26	30	24	69	2.80	-.6	13	11.7	nw.	36	w.	28	9	6	16	6.4	1.9	.1
Nantucket	12	14	90	30.02	30.03	-.02	38.1	+2.3	57	6	44	20	29	33	22	36	33	83	5.60	+1.9	17	15.4	nw.	41	n.	20	7	9	15	6.3	1.1	T
Block Island	26	11	46	30.02	30.05	-.01	37.7	+1.7	57	5	43	18	2	32	26	35	30	73	3.44	-.4	15	19.1	n.	45	w.	28	12	7	12	5.3	.5	.4
Providence	159	215	251	29.88	30.06	.00	34.2	+2.6	57	5	41	13	2	28	33	31	27	75	3.31	-.1	13	12.0	nw.	54	nw.	28	12	4	15	5.7	2.4	T
Hartford	159	66	100	29.88	30.06	-.01	32.4	+2.6	55	4	38	10	3	26	25				3.86	-.1	14	8.5	n.	35	nw.	28	7	8	16	6.6	4.4	.1
New Haven	106	74	153	29.95	30.07	.00	34.2	+1.7	56	4	40	14	3	28	37	31	26	71	3.53	-.5	15	9.6	n.	32	e.	27	8	5	18	6.4	2.0	T
Middle Atlantic States							37.1	+1.5										72	2.59	-0.7										6.3		
Albany [1]	292	26	37	29.73	30.05	-.03	28.4	-.1	52	4	35	1	2	22	40	26	22	75	3.33	+.7	13	9.1	s.	42	nw.	28	8	1	22	7.5	5.8	2.7
Binghamton	871	57	79	29.11	30.07	-.02	30.6	+2.4	55	5	37	9	2	24	27	28	23	76	3.26	+1.0	16	7.4	nw.	28	se.	27	1	4	26	9.1	4.4	.9
New York	314	415	454	29.72	30.07	-.02	37.2	+2.2	58	4	44	18	2	31	28	33	27	66	2.18	-1.4	14	15.7	nw.	52	nw.	10	7	8	16	6.6	1.1	.1
Harrisburg	374	94	104	29.68	30.10	-.02	34.1	+1.4	52	7	40	17	28	28	19	30	24	69	3.65	+.6	11	7.6	w.	27	w.	27	8	8	15	6.5	3.2	.0
Philadelphia	114	174	367	29.97	30.10	-.01	37.6	+1.3	59	5	44	20	28	31	27	33	28	69	2.22	-1.2	10	12.2	nw.	37	s.	3	7	10	14	6.4	.2	.0
Reading	323	283	306	29.74	30.11		35.4	+3.2	58	5	42	17	29	29	27	31	25	66	1.98	-1.6	11	11.6	nw.	57	s.	27	8	12	11	6.1	.2	.0
Scranton	805	72	104	29.18	30.08	-.02	32.0	+1.3	55	4	38	13	29	26	28	29	25	74	3.51	+.5	12	6.8	sw.	30	sw.	27	2	9	20	7.7	4.2	T
Atlantic City	52	37	172	30.04	30.10	.00	39.4	+3.0	57	8	46	20	29	33	26	36	31	72	1.82	-2.1	9	15.2	w.	47	se.	5	7	6	18	6.5	T	.0
Sandy Hook	22	10	57	30.05	30.07		37.2	+2.0	55	4	42	21	28	32	26	34	30	76	2.07	-2.0	13	15.6	w.	44	w.	27	10	6	15	6.3	.6	T
Trenton	190	159	107	29.88	30.09		35.7	+1.3	59	5	42	17	2	29	26	32	27	71	2.11	-1.2	10	9.1	nw.	27	nw.	10	7	7	17	7.0	T	.0
Baltimore	123	100	215	29.98	30.11	-.02	39.4	+2.2	56	5	46	20	28	33	23	34	27	66	2.66	-.7	9	9.9	sw.	32	sw.	6	7	11	13	6.0	.4	.0
Washington	112	62	85	29.98	30.11	-.02	38.4	+1.8	59	5	45	20	28	32	25	34	28	69	2.69	-.6	12	6.6	nw.	26	nw.	10	11	6	14	6.1	T	.0
Cape Henry	18	8	54	30.08	30.10		44.6	+.9	68	5	51	27	29	38	25	42	39	83	2.39	-1.0	11	13.4	n.	40	nw.	21	13	7	11	5.0	.0	.0
Lynchburg	686	144	184	29.37	30.14	.00	40.0	+.5	62	12	48	14	29	32	27	34	28	67	4.18	+.9	8	7.0	sw.	36	nw.	10	11	7	13	5.3	1.0	.0
Norfolk	91	80	125	30.02	30.12	-.01	45.2	+2.1	68	5	52	27	29	38	27	40	35	73	2.45	-.9	10	10.1	sw.	30	nw.	21	13	4	14	5.8	.0	.0
Richmond	144	11	52	29.97	30.13	-.01	40.8	+1.0	68	12	49	18	29	32	27	35	31	75	2.61	-.7	10	8.0	sw.	24	w.	10	15	5	11	4.7	T	.0
Wytheville	2,304	49	55	27.66	30.12	-.03	35.0	-.3	58	4	43	14	28	27	26	30	27	76	.93	-2.0	5	7.8	w.	25	w.	10	12	6	13	4.8	4.1	T
South Atlantic States							47.6	+0.2										74	3.03	-0.4										5.2		
Asheville	2,253	89	104	27.73	30.16	.00	39.4	+1.6	64	4	49	15	28	29	34	33	28	69	2.22	-1.0	8	8.9	nw.	26	nw.	27	9	13	9	5.6	2.7	.0
Charlotte	779	63	86	29.28	30.13	-.03	43.2	+.2	70	12	52	25	28	35	28	38	32	68	3.65	-.2	11	6.9	sw.	28	sw.	9	12	8	11	5.1	T	.0
Greensboro [1]	886	6	56	29.17	30.15		39.1		67	12	50	17	29	28	31	34	30	81	3.24		11	7.0	sw.	24	sw.	9	15	4	12	4.9	T	.0
Hatteras	11	5	50	30.09	30.10	-.03	50.0	-.1	67	5	56	34	29	44	24	46	44	83	8.98	+4.8	10	14.9	n.	43	s.	26	13	5	13	5.5	.0	.0
Raleigh	376	103	140	29.71	30.13	-.02	44.0	+1.0	70	12	53	24	29	35	29	39	35	77	2.93	-.6	10	8.3	sw.	23	sw.	26	13	9	9	4.6	.0	.0
Wilmington	72	73	107	30.05	30.12	-.03	49.4	+.3	72	12	59	29	28	40	27	44	40	78	3.15	+.4	10	8.5	n.	33	w.	9	11	9	11	5.3	.0	.0
Charleston	48	11	92	30.08	30.13	-.02	50.9	-.8	72	4	59	34	28	43	24	46	41	76	1.14	-1.6	8	9.4	n.	32	sw.	9	11	11	9	5.3	.0	.0
Columbia, S. C.	347	70	91	29.75	30.14	-.02	47.4	+.2	72	12	57	27	28	38	29	40	34	66	2.46	-.6	6	8.0	ne.	27	sw.	9	13	9	9	4.6	.0	.0
Greenville, S. C.	1,040	70	78	29.00	30.12		43.4	+1.2	69	12	52	25	28	35	26	37	31	67	2.58	-2.3	8	6.6	ne.	26	sw.	9	12	7	12	5.0	.0	.0
Augusta	182	62	77	29.93	30.13	-.03	48.0	-.1	72	12	59	27	28	37	37	41	36	70	3.99	+.7	7	5.5	nw.	21	w.	9	12	7	12	5.4	.0	.0
Savannah	65	73	152	30.05	30.12	-.03	52.5	+.1	78	4	62	34	28	43	32	45	41	77	1.60	-1.3	6	10.2	w.	36	nw.	9	11	9	11	5.3	.0	.0
Jacksonville	43	86	110	30.08	30.14	.00	55.2	-1.1	78	4	65	34	28	45	29	48	44	76	.68	-2.3	6	7.5	n.	31	nw.	9	11	9	11	5.2	.0	.0
Florida Peninsula							64.8	-0.4										79	1.26	-0.8										3.4		
Key West	21	10	64	30.04	30.06	-.02	70.0	-.3	81	5	75	57	19	65	17	64	62	83	.26	-1.4	8	9.0	ne.	24	n.	16	24	5	2	2.4	.0	.0
Miami	25	124	168	30.05	30.08	-.03	68.4	+.4	81	27	76	50	19	61	25	61	58	76	2.73	+1.0	7	8.7	n.	25	n.	16	15	11	5	3.8	.0	.0
Tampa	35	88	197	30.08	30.12	.00	61.2	+.1	79	26	71	40	11	52	30	54	51	77	.29	-1.8	4	10.6	ne.	26	nw.	5	15	10	6	4.1	.0	.0
Titusville	43	5	36				59.8	-1.9	82	4	71	35	10	48	34	54	52		1.67	-1.0	4		nw.				13	9	9		.0	.0
East Gulf States							49.6	-0.4										72	2.95	-1.9										5.6		
Atlanta [1]	976	5	53	29.08	30.13	-.03	43.6	-1.1	63	11	53	20	28	35	33	38	33	75	2.94	-1.8	10	9.6	nw.	27	w.	9	9	6	16	5.9	T	.0
Macon	370	79	87	29.74	30.14	-.02	47.7	+.2	72	4	59	24	28	37	36	41	34	66	2.36	-1.6	7	6.5	nw.	20	s.	26	8	10	13	5.9	.0	.0
Thomasville	273	49	58				52.6	+.1	78	4		30	28	36					2.75	-1.5			nw.				15	5	11			
Apalachicola	35	11		30.09	30.13	-.03	54.5	-1.2	76	24	63	34	28	46	26	50	46	81	2.38	-2.7	8	8.1	n.	26	nw.	9	14	7	10	4.7	.0	.0
Pensacola	56	149	185	30.08	30.14	-.01	53.2	-.8	70	11	61	29	28	46	22	48	44	74	2.45	-2.2	9	11.4	n.	43	s.	26	15	4	12	4.8	.0	.0
Anniston	741	9					45.4	+1.2	68	4	55	21	28	36	34				2.61	-2.4	9		nw.				12	4	15		.0	.0
Birmingham	700	11	48	29.38	30.13	-.03	46.0	-.4	70	11	55	20	28	37	28	40	36	67	2.09	-3.0	13	7.1	n.	24	se.	3	11	7	13	5.5	.0	.0
Mobile	57	86	161	30.08	30.15	.00	51.2	-1.0	70	11	61	29	28	42	33	46	42	76	3.20	-1.8	9	9.1	n.	37	se.	26	11	5	15	5.4	.0	.0
Montgomery	218	92	105	29.90	30.15	.00	48.7	-.7	74	11	58	27	28	39	33	43	38	68	2.48	-2.4	9	6.6	n.	21	w.	5	10	6	15	6.0	.0	.0
Meridian	375	67	92	29.74	30.15	-.01	47.6	-1.1	75	11	58	24	28	38	34	41	36	73	4.06	-1.2	10	5.5	sw.	20	sw.	11	10	8	13	5.7	.0	.0
Vicksburg	247	82	102	29.87	30.14	-.01	49.4	-.6	75	11	57	24	28	42	31	43	36	67	3.50	-1.8	13	8.4	n.	24	nw.	8	8	5	18	6.7	.0	.0
New Orleans	53	76	84	30.09	30.15	+.02	55.6	.0	79	23	64	33	28	47	27	50	45	74	4.59	-.2	9	7.0	ne.	21	e.	25	11	11	9	4.9	.0	.0
West Gulf States							52.1	+1.7										68	2.43	-0.6										5.2		
Shreveport	249	92	227	29.87	30.15	+.02	50.2	+1.1	77	11	59	23	28	42	37	44	39	70	3.15	-1.1	9	11.0	ne.	34	s.	2	12	5	14	5.5	.0	.0
Bentonville	1,303	12	38	28.74	30.14	+.01	40.1	+2.6	65	2	50	11	27	31	30				1.07	-1.3	8	7.0	s.	21	s.	2	13	7	11		.3	.0
Fort Smith	463	57	82	29.65	30.14	+.01	43.6	+1.5	71	10	53	17	27	34	35	37	30	64	1.18	-1.6	6	7.6	e.	24	n.	8	11	13	7	4.7	T	.0
Little Rock	357	94	102	29.75	30.14	.00	44.6	+.4	72	11	53	21	27	37	33	39	32	64	3.34	-.8	10	8.4	nw.	27	nw.	8	13	4	14	5.4	T	.0
Austin	605	68	90	29.48	30.12		53.6	+2.6	80	10	64	26	28	44	36	46	38	63	1.75	-.9	5	7.8	n.	27	sw.	10	14	6	11	4.8	.0	.0
Brownsville	57	88	96	30.00	30.06		63.4	+2.2	82	4	71	46	28	55	27	57	53	76	1.80	+.2	9	10.9	se.	30	sw.	10	14	10	7	5.0	.0	.0
Corpus Christi	20	11	78	30.08	30.10	-.02	60.2	+2.2	80	4	68	36	27	53	30	54	51	76	6.44	+5.0	7	10.9	s.	30	s.	10	9	9	13	5.8	.0	.0
Dallas	512	220	227	29.56	30.12		48.6		80	4	58	22	28	39	31	41	32	57	1.00	-1.4	4	11.4	n.	33	s.	10	10	10	11	5.2	.0	.0
Fort Worth	679	92	110	29.40	30.12	.00	48.9	+1.4	84	10	59	22	27	38	33				1.26	-.6	5	9.8	n.	31	n.	26	11	11	9	4.7	.0	.0
Galveston	54	106	114	30.06	30.12	.00	58.0	+1.6	71	10	63	37	28	53	17	54	50	79	2.71	-1.0	11	10.6	n.	26	n.	27	14	6	11	5.0	.0	.0
Houston	138	157	190	29.98	30.14		56.4	+2.0	79	11	64	31	27	48	25				3.31	-.9	13	10.5	n.	27	se.	2	12	3	16	5.8	.0	.0
Palestine	510	64	72	29.60	30.14	+.02	50.8	+.9	77	10	60	25	27	42	31	44	37	66	3.14	-.5	7	7.6	s.	25	sw.	11	9	9	13	5.6	.0	.0
Port Arthur	34	59	134	30.09	30.13		55.2		74	23	63	33	27	48	26				2.61	-2.6	9	12.7	n.	31	ne.	25	11	5	15	5.7	.0	.0
San Antonio	693	111	301	29.38	30.10	-.01	55.8	+2.1	81	4	66	29	27	46	33	47	38	59	1.24	-.4	6	11.3	n.	32	nw.	26	15	5	11	4.8	.0	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, December 1938*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
							37.5	+1.0										70	1.65	−1.9										6.5		
Chattanooga	762	71	214	29.31	30.14	−.02	43.8	+.5	63	2	52	20	28	35	28	38	30	62	2.30	−2.8	7	7.5	w.	28	w.	9	11	9	11	5.1	T	0.0
Knoxville	995	66	84	29.06	30.14	−.02	39.8	−.5	61	1	49	19	28	31	31	35	30	73	2.71	−1.8	10	5.2	e.	24	w.	27	9	13	9	4.9	0.3	.0
Memphis	399	78	86	29.70	30.13	−.02	43.8	+.2	71	11	52	21	28	36	28	38	31	64	2.36	−2.2	10	8.0	sw.	22	nw.	26	10	8	13	5.6	.0	.0
Nashville	546	168	188	29.56	30.16	+.01	41.6	+.6	64	11	51	16	28	32	29	36	30	68	2.00	−2.2	8	8.6	nw.	31	se.	3	10	7	14	5.6	T	.0
Lexington	989	6					37.2	+1.4	64	2	46	9	28	28	30				1.69	−2.1	8		e.				10	11	10		.1	.0
Louisville	525	188	234	29.53	30.11	−.03	38.0	+.4	62	2	46	14	28	30	27	33	28	68	1.38	−2.4	9	10.3	s.	34	w.	27	11	8	12	5.5	T	.0
Evansville	431	76	116	29.64	30.12	−.01	37.8	+.7	59	4	45	15	28	30	28	33	28	70	1.54	−2.0	8	8.9	s.	30	nw.	27	7	7	17	6.6	.9	.0
Indianapolis	718	194	230	29.18	30.09	−.03	34.3	+2.1	55	4	41	9	28	28	31	30	25	70	1.46	−1.5	11	8.1	w.	27	w.	26	4	10	17	7.3	.6	.0
Terre Haute	575	63	149	29.45	30.08		34.4		56	4	42	12	28	27	33	30	25	71	1.88	−1.0	10	9.6	sw.	30	w.	27	7	12	12	6.0	T	.0
Cincinnati	627	11	51	29.41	30.11	−.02	36.4	+3.0	62	2	44	10	28	29	30	32	26	70	1.41	−1.6	7	8.4	sw.	30	sw.	27	6	6	19	6.5	.2	.0
Columbus	822	90	210	29.19	30.09	−.03	34.8	+2.4	57	4	41	8	28	28	27	31	26	71	1.04	−1.7	6	10.4	s.	37	w.	27	5	6	20	7.2	.3	.0
Dayton	900	186	213	29.10	30.08		35.0	+2.4	57	4	42	7	28	28	28	31	26	72	1.31	−1.4	7	10.7	sw.	37	w.	27	8	4	19	7.0	2.1	T
Elkins	1,947	65	83	28.01	30.12	.00	33.7	+1.0	61	4	43	9	28	24	38	30	25	75	1.69	−1.8	14	7.1	w.	28	w.	27	6	8	17	7.3	1.2	.0
Parkersburg	637	77	84	29.40	30.11	−.03	36.0	+.8	60	4	43	12	28	29	26	32	28	76	1.15	−1.9	10	6.6	se.	24	w.	27	9	3	19	6.7	T	.0
Pittsburgh [1]	1,273	39	54	28.68	30.08	−.03	32.8	−1.4	56	4	39	8	28	27	30	29	25	74	.80	−2.0	12	11.4	sw.	36	w.	27	3	9	19	7.7	2.3	.0
Lower Lake Region							30.9	+1.5										78	1.91	−0.8										8.6		
Buffalo	768	243	280	29.17	30.03	−.03	31.3	+1.5	55	5	37	10	31	26	25	29	25	80	2.27	−1.1	17	17.6	w.	66	sw.	27	1	5	25	8.6	14.2	6.1
Canton	448	10	61	29.53	30.03		24.5	+1.8	54	5	32	−12	15	16	31	23	20	86	2.32	−.4	21	8.9	sw.	35	w.	28	5	5	21	7.7	11.6	3.3
Ithaca	836	77	100	29.12	30.06		30.4	+1.4	56	5	37	8	2	24	27	28	25	81	2.42	.0	12	9.5	nw.	36	se.	26	1	3	27	9.1	~~8.3~~	~~5.3~~
Oswego	335	71	85	29.66	30.04	−.02	31.1	+2.1	56	5	37	12	2	25	22	28	28	73	1.54	−2.0	20	11.7	se.	36	w.	28	1	0	30	9.8	8.6	4.1
Rochester	523	86	102	29.46	30.05	−.01	31.8	+2.5	59	5	37	11	31	27	25	28	24	76	1.24	−1.5	20	9.4	sw.	34	sw.	27	1	5	25	8.9	8.3	2.2
Syracuse	596	65	79	29.38	30.04	−.03	31.4	+2.4	58	5	37	7	16	26	28				2.72	−.4	23	8.3	w.	26	sw.	27	1	4	26	8.7	27.1	5.0
Erie	690	57	81	29.26	30.05	−.02	32.6	+.7	55	5	38	13	27	28	26	30	26	76	1.93	−.9	16	10.4	sw.	30	w.	27	1	3	27	9.1	10.2	1.5
Cleveland	762	267	318	29.20	30.05	−.04	33.5	+2.3	56	4	39	10	28	28	30	30	25	74	1.72	−.7	15	16.3	sw.	49	sw.	27	0	8	23	8.7	7.8	1.6
Sandusky	629	5	67	29.36	30.07	−.02	32.4	+1.2	53	4	38	7	28	27	26				1.71	−.6	13	9.9	sw.	31	sw.	27	0	8	23	8.6	2.7	.1
Toledo	628	79	87	29.37	30.07	−.01	31.0	+.6	49	4	36	5	28	26	26	28	24	76	1.57	−.8	14	10.2	w.	35	w.	27	2	11	18	7.6	2.7	.6
Fort Wayne	857	69	84	29.12	30.07		30.8	+1.1	51	4	37	3	28	25	29	28	25	80	1.98	−.6	14	10.1	w.	35	w.	27	4	9	18	7.3	5.0	.8
Detroit [1]	620	5	78	29.34	30.04	−.03	30.2	+.9	47	4	36	7	28	25	23	28	24	79	1.54	−.8	14	11.2	sw.	42	sw.	27	1	2	28	8.8	6.1	3.2
Upper Lake Region							25.5	+1.6										80	1.88	−0.1										8.2		
Alpena	609	13	80	29.29	29.98	−.04	28.2	+3.4	44	5	33	3	30	24	21	26	22	79	1.93	−.2	15	11.4	sw.	35	nw.	27	0	4	27	8.9	12.2	5.7
Escanaba	612	41	49	29.30	29.99	−.04	24.4	+2.0	40	9	30	−13	30	18	30	22	18	77	2.01	+.3	16	10.9	nw.	31	nw.	27	2	6	23	8.4	13.3	5.4
Grand Rapids	707	70	244	29.23	30.03	−.02	30.4	+1.9	49	4	36	10	30	25	20	28	25	80	1.80	−.8	17	11.1	sw.	36	sw.	13	1	3	27	8.9	10.8	6.1
Lansing	878	5	90	29.06	30.03		28.2	+1.0	46	5	34	4	28	22	23	26	24	85	2.07	.0	19	9.2	sw.	25	w.	27	2	3	26	8.6	11.7	7.5
Marquette	734	44	69	29.13	29.96	−.06	23.8	+1.2	37	4	29	−9	30	19	22	22	20	84	2.97	+.3	18	8.9	w.	32	sw.	13	2	4	25	8.6	19.7	10.5
Sault Sainte Marie	614	11	52	29.26	29.98	−.02	24.2	+3.7	41	3	30	−5	31	19	28	23	20	84	3.36	+1.0	23	8.9	se.	38	nw.	14	3	2	26	8.7	29.3	14.7
Chicago	673	7	131	29.30	30.06	−.02	29.2	+.4	53	4	35	2	28	23	28	27	22	74	1.18	−.9	9	10.4	w.	28	w.	27	6	3	22	7.5	3.5	.3
Green Bay	617	100	141	29.31	30.01	−.03	23.4	+1.1	45	4	30	−14	30	17	26	22	18	78	1.33	−.4	12	10.1	sw.	31	nw.	27	3	7	21	8.1	7.5	2.4
Milwaukee	681	97	221	29.26	30.02	−.04	27.4	+1.3	46	3	33	−6	30	21	27	26	21	75	1.10	−.6	11	12.1	w.	34	s.	22	4	8	19	7.7	4.2	1.6
Duluth	1,133	5	47	28.71	29.98	−.07	15.8	−.1	38	10	23	−26	30	9	31	15	12	86	1.10	.0	9	12.4	nw.	50	nw.	26	10	3	18	6.6	12.3	9.1
North Dakota							17.5	+5.4										83	0.44	−0.2										6.2		
Moorhead, Minn.	940	50	58	28.97	30.03	−.05	16.1	+4.6	38	3	24	−23	29	8	30	16	14	88	.52	−.2	9	8.8	s.	24	n.	26	3	8	20	7.7	5.8	3.1
Bismarck	1,677	8	57	28.17	30.03	−.05	21.8	+7.1	50	9	31	−26	29	13	31	19	15	78	.16	−.4	5	8.7	w.	30	w.	10	9	11	11	5.6	3.1	1.7
Devils Lake	1,478	11	44	28.36	30.00	−.06	15.2	+5.7	41	3	23	−31	29	8	25	14	12	86	.43	−.1	9	9.5	nw.	34	n.	26	9	4	18	6.6	5.6	3.4
Grand Forks	833	12	67				13.0	+2.4	37	3	22	−28	30	4	32	13	11		.63	.0	6	10.6	se.				3	8	20		6.0	6.5
Williston	1,878	42	50	29.76	30.01	−.05	21.2	+7.4	47	9	30	−31	29	12	34	18	15	81	.47	−.1	9	7.6	w.	27	w.	25	12	12	7	5.0	4.4	3.3
Upper Mississippi Valley							28.7	+1.6										76	1.18	−0.5										6.5		
Minneapolis-St. Paul, Minn.[1]	848	32	61	29.08	30.03	−.05	20.4	+.8	45	3	28	−16	29	13	35	18	16	83	.77	−.2	9	10.8	nw.	34	nw.	26	2	11	18	7.9	9.1	6.4
La Crosse	714	11	48	29.24	30.05	−.03	23.6	+1.3	43	4	30	−8	30	17	27	22	18	79	1.10	−.2	12	6.3	s.	18	nw.	27	6	6	19	7.2	8.2	3.9
Madison	974	70	78	28.94	30.04	−.04	24.2	+1.4	44	4	30	−7	30	18	26	23	19	80	.89	−.7	12	9.1	nw.	23	nw.	27	5	4	22	7.8	5.6	3.0
Charles City	1,015	10	51	28.93	30.06	−.04	23.0	+2.6	40	4	30	−6	27	16	33	21	18	81	1.13	−.2	9	7.2	nw.	21	nw.	27	6	8	17	6.9	7.7	3.3
Davenport	606	66	161	29.39	30.08	−.02	28.7	+1.6	49	4	36	0	30	22	30	26	21	73	.74	−.7	7	10.0	nw.	32	nw.	27	6	7	18	6.5	2.7	1.0
Des Moines	861	5	99	29.13	30.07	−.04	28.5	+2.5	53	3	37	−1	30	20	34	26	21	75	.74	−.5	5	10.1	nw.	30	nw.	26	10	13	8	5.2	4.8	.1
Dubuque	690	60	70	29.28	30.06	−.04	26.0	+1.3	48	4	33	−7	30	19	28	24	20	77	.97	−.5	10	6.8	nw.	22	nw.	27	7	5	19	7.1	7.3	3.0
Keokuk	614	64	78	29.40	30.08	−.04	31.4	+1.8	56	2	39	4	27	24	31	28	23	72	1.15	−.3	6	7.6	nw.	29	w.	26	8	8	15	6.4	2.6	T
Cairo	358	87	93	29.73	30.12	−.03	39.5	+1.7	64	1	47	17	28	32	27	35	28	67	1.35	−2.0	8	8.8	sw.	27	se.	3	10	6	15	6.0	T	.0
Peoria	609	11	45	29.40	30.08	−.03	30.0	+1.9	54	4	37	4	27	23	31	27	24	80	1.43	−.3	5	6.8	w.	23	w.	26	9	9	13	5.2	.9	T
Springfield, Ill.	636	5	191	29.40	30.08	−.04	32.7	+1.0	56	4	39	9	27	26	33	30	25	74	1.85	−.3	6	11.6	w.	35	w.	27	7	6	18	6.6	.5	.0
St. Louis	568	179	303	29.47	30.09	−.04	36.4	+1.5	62	1	43	13	27	30	33	32	25	66	2.06	−.2	8	11.6	nw.	32	nw.	26	11	7	13	5.5	.2	.0
Missouri Valley							32.6	+4.2										65	0.71	−0.4										4.9		
Columbia, Mo.	784	6	66	29.22	30.08	−.04	35.6	+2.4	61	1	44	10	30	27	34				3.22	+1.4	7	8.2	w.	25	nw.	26	10	9	12	5.7	T	.0
Kansas City [1]	750	32	45	29.26	30.09	−.03	36.1	+3.6	61	3	46	9	27	26	32	31	24	65	.55	−.8	4	8.9	sw.	33	nw.	26	13	10	8	4.7	T	.0
St. Joseph	967	11	49	29.02	30.08		34.4	+4.8	57	3	44	6	27	25	33	30	23	68	.65	−.6	4	8.9	nw.	34	nw.	26	17	8	6	3.7	T	.0
Springfield, Mo.	1,324	5	78	28.66	30.10	−.03	38.2	+2.0	66	2	46	11	27	30	26	33	27	67	1.28	−1.0	6	9.0	w.	27	nw.	27	16	7	8	4.5	.3	.0
Topeka	987	65	87	29.01	30.09		36.4	+4.4	62	31	47	8	27	26	38	31	22	59	.24	−.7	4	9.0	w.	31	nw.	26	11	12	8	4.5	T	.0
Lincoln	1,189	11	81	28.77	30.08	−.04	32.8	+5.2	60	3	43	3	29	23	33	27	20	63	.26	−.5	3	9.3	w.	38	nw.	26	14	10	7	4.5	1.4	.0
Omaha [1]	982	31	44	29.00	30.08	−.03	30.6	+4.2	55	3	40	3	29	21	34	26	21	74	.15	−.9	3	10.6	nw.	42	nw.	26	12	7	12	5.1	.6	.0
Valentine	2,598	47	54	27.26	30.07	−.03	28.6	+4.0	62	9	42	−9	27	15	43	24	17	64	.06	−.6	3	9.8	w.	32	nw.	26	7	17	7	5.0	.9	.0
Sioux City	1,138	64	106	28.81	30.07	−.05	28.0	+4.9	55	3	37	−3	29	19	37	24	18	68	.45	−.4	4	10.1	nw.	43	nw.	26	9	7	15	6.0	3.9	T
Huron	1,307	50	74	28.61	30.06	−.04	25.4	+6.7	52	25	35	−12	29	16	36	21	15	68	.22	−.4	6	9.7	nw.	32	nw.	26	9	13	9	5.1	2.6	T
Northern Slope							27.6	+3.9										67	0.55	−0.2										6.5		
Havre	2,507	11	67	27.33	30.05	.00	26.4	+6.0	54	8	37	−13	29	16	52	23	17	70	.78	+.2	6	10.2	sw.	33	sw.	5	8	11	12	6.1	12.7	4.9
Helena	4,124	85	111	25.80	30.12	−.01	28.5	+4.3	59	8	37	−10	26	20	48	24	16	58	.23	−.6	6	8.0	sw.	31	sw.	5	3	8	20	8.0	4.4	.7
Missoula	3,263	80	91				31.4	+6.9	60	8	38	7	26	25	35				.40	−.7	10	5.5	w.	32	sw.	25	1	9	21	8.2	2.6	.0
Kalispell	2,973	48	56	27.00	30.15	+.08	27.5	+2.6	56	8	34	2	26	21	28	26	22	80	1.13	−.3	13	4.7	nw.	28	ne.	25	2	5	24	8.7	16.8	3.3
Miles City	2,371	48	55	27.49	30.06	−.04	27.8	+6.8	54	9	38	−13	30	18	57	23	17	66	.32	−.3	3	6.9	s.	35	nw.	25	7	10	14	6.1	6.9	5.8
Rapid City	3,259	50	58	26.58	30.04	−.05	29.6	+2.7	59	5	41	−5	27	18	56	25	16	56	.08	−.4	2	8.5	nw.	35	nw.	26	8	13	10	5.6	.8	.0
Cheyenne [1]	6,144	5	39	23.90	30.10	+.01	27.4	−1.1	56	9	38	−8	12	17	43	23	18	70	.97	+.4	9	15.8	nw.	52	nw.	3	11	8	12	5.8	11.7	T
Lander	5,352	60	68	24.64	30.14	−.01	24.0	+3.6	55	9	37	−9	13	12	35	20	14	69	.44	−.2	4	4.6	sw.	32	w.	3	11	13	7	4.8	6.0	.2
Sheridan	3,790	10	47	26.14	30.10		27.3		56	25	30	−5	26	15	49	23	16	65	.85	+.2	6	5.6	nw.	27	nw.	5	8	10	13	5.6	2.1	.0
Yellowstone Park	6,241	12	46	23.88	30.23	+.07	23.2	+3.5	43	5	31	−8	12	15	33	21	16	70	.68	−.1	14	9.0	sw.	35	sw.	25	5	9	17	6.8	8.9	1.8
North Platte	2,821	11	51	27.08	30.10	.00	30.0	+3.3	61	9	43	−2	27	17	40	25	19	70	.16	−.4	2	7.9	w.	30	n.	26	11	8	12	5.5	1.8	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, December 1938*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air												Precipitation			Wind										
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01 inch or more	Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Middle Slope							36.7	+3.2										57	0.28	−0.5										4.2		
Denver	5,292	106	113	24.71	30.08	0.00	33.9	+1.6	63	9	44	3	27	24	41	28	18	56	.62	−.1	7	8.0	s.	27	ne.	3	8	15	8	5.2	9.3	0.0
Pueblo	4,680	79	86	25.29	30.07	−.01	35.0	+3.5	72	9	48	4	27	22	49	29	21	58	.47	.0	5	6.9	nw.	37	nw.	3	16	9	6	4.2	5.2	.0
Concordia	1,392	50	58	28.58	30.10	−.01	34.5	+3.8	62	3	46	3	27	23	34	28	20	59	.02	−.6	1	8.9	w.	35	nw.	26	16	8	7	3.7	T	.0
Dodge City	2,500	10	86	27.43	30.10	.00	36.6	+4.0	63	9	49	2	27	24	39	29	19	54	.06	−.5	1	11.2	nw.	32	nw.	4	18	5	8	3.9	1.2	.0
Wichita	1,358	85	93	28.63	30.10	−.01	38.0	+3.4	61	3	48	9	27	28	30	32	22	54	.15	−.8	1	9.6	nw	32	nw.	26	18	7	6	3.5	T	.0
Oklahoma City	1,214	10	47	28.80	30.11	.00	42.0	+2.7	69	1	52	15	27	32	28	35	26	60	.38	−1.1	5	9.6	s.	28	n.	26	14	8	9	4.6	.9	.0
Southern Slope							46.1	+2.0										50	0.41	−0.4										4.0		
Abilene	1,738	10	56	28.27	30.12	+.01	47.4	+1.4	79	10	59	19	27	36	37	38	25	49	.44	−.9	3	9.1	s.	29	s.	28	14	8	9	4.5	.0	.0
Amarillo	3,676	10	49	26.30	30.09	.00	41.9	+4.9	75	9	54	14	27	30	43	32	19	47	.08	−.7	2	9.3	w.	32	sw.	3	15	10	6	4.2	1.0	.0
Del Rio	960	63	71	29.08	30.09	−.01	53.1	+.9	80	2	64	32	27	42	42	44	33	54	.80	+.2	2	7.6	se.	30	w.	2	17	4	10	4.3	.0	.0
Roswell	3,566	75	85	26.43	30.10	+.03	41.9	+.7	73	10	56	15	28	28	48	34	21	49	.24	−.4	3	6.4	s.	33	nw.	2	20	7	4	3.2	.0	.0
Southern Plateau							44.2	+3.5										55	0.98	+0.1										3.7		
El Paso	3,778	82	101	26.25	30.08	+.05	48.4	+3.5	74	9	61	23	3	35	41	38	24	42	.28	−.2	5	7.0	w.	23	nw.	25	22	7	2	2.4	.0	.0
Albuquerque [1]	5,314	5	39	25.10	30.11	......	37.7	+3.2	66	10	52	13	14	24	41	30	22	59	.36	−.1	4	7.6	n.	32	nw.	2	17	6	8	4.0	.1	.0
Santa Fe	7,013	38	53	23.25	30.11	+.05	34.4	+3.7	54	5	44	16	31	25	29	27	18	54	.45	−.3	5	6.0	n.	19	n.	2	15	7	9	4.1	3.4	.0
Flagstaff	6,907	10	59	23.36	30.07	+.01	32.1	+3.7	61	5	46	0	25	18	46	27	......	71	2.84	+.8	7	6.2	n.	22	nw.	1	10	12	9	......	17.0	2.0
Phoenix	1,107	39	51	28.88	30.04	.00	55.9	+3.9	82	8	69	35	26	43	42	46	36	55	1.14	+.1	5	4.7	e.	18	se.	15	13	8	10	4.8	.0	.0
Yuma	141	9	54	29.91	30.06	+.01	58.0	+2.8	83	7	69	38	29	47	35	48	36	49	.88	+.4	5	5.8	n.	21	n.	23	18	8	5	3.1	.0	.0
Independence	3,957	5	26	......	......	......	43.1	+3.8	76	7	54	24	28	32	33	35	24	......	.89	+.1	6	......	nw.	......	......	......	17	8	6	......	......	......
Middle Plateau							32.7	+3.0										71	0.51	−0.4										6.1		
Reno	4,527	61	76	25.58	30.19	+.04	37.0	+3.7	62	4	49	16	12	25	37	32	25	61	.11	−.9	1	4.8	sw.	24	w.	3	12	9	10	4.5	T	.0
Tonopah	6,090	12	20	......	......	......	35.6	......	56	7	42	13	12	29	19	32	27	73	.81	......	4	......	se.	......	......	......	......	......	......	......	6.6	T
Winnemucca	4,344	18	56	25.74	30.23	+.05	33.2	+3.2	60	7	48	3	13	19	39	28	21	62	.06	−1.0	2	7.9	ne.	26	sw.	2	6	15	10	6.0	.5	.0
Modena	5,473	10	43	24.69	30.15	+.03	31.3	+3.2	60	5	43	7	13	20	39	27	22	73	.76	−.1	6	7.4	w.	26	w.	3	6	12	13	6.5	5.9	1.1
Salt Lake City [1]	4,227	32	46	25.85	30.21	+.06	34.1	......	56	5	41	17	14	27	21	31	28	80	1.41	......	6	6.6	se.	22	s.	3	6	7	18	7.2	2.8	.0
Grand Junction	4,602	60	68	25.50	30.18	+.08	29.2	+1.7	53	4	39	5	29	20	32	26	22	76	1.12	+.5	6	4.1	se.	27	s.	21	9	5	17	6.2	9.2	.4
Northern Plateau							34.3	+3.1										76	0.73	−1.0										7.4		
Baker	3,471	36	54	26.58	30.25	+.00	30.2	+2.9	48	8	38	7	13	22	25	28	26	82	.19	−1.5	5	5.3	s.	17	se.	27	5	5	21	7.5	2.8	T
Boise	2,739	79	87	27.34	30.28	+.08	34.2	+2.1	51	2	41	16	13	27	22	31	27	77	.57	−1.0	6	4.3	se.	23	nw.	25	6	7	18	6.8	.1	.0
Pocatello [1]	4,466	5	31	25.57	30.22	+.03	30.0	......	56	8	38	−4	12	22	29	28	25	82	.87	......	10	9.8	sw.	37	w.	25	5	5	21	7.5	7.2	T
Spokane	1,929	101	110	28.07	30.18	+.10	32.8	+2.3	56	8	39	12	12	27	20	31	26	76	1.63	−.6	11	6.5	s.	26	sw.	2	6	5	20	7.5	9.2	.0
Walla Walla	991	57	65	29.11	30.20	+.08	39.1	+3.6	65	7	45	18	13	33	25	35	30	71	.86	−1.2	10	5.8	s.	32	w.	2	3	5	23	8.3	2.2	
Yakima	1,076	58	67	29.01	30.19	......	35.2	+4.5	57	30	43	13	14	27	29	32	27	71	.41	−.9	7	4.4	nw.	26	nw.	25	7	6	18	6.9	.5	.0
North Pacific Coast Region							43.1	+1.5										82	5.14	−2.0										8.0		
North Head	211	11	56	29.91	30.14	+.11	44.6	+.5	53	31	48	34	19	41	15	43	40	85	6.55	−2.9	20	15.6	s.	67	s.	31	4	7	20	7.6	.0	.0
Seattle	125	90	321	29.99	30.12	+.11	44.0	+2.3	59	4	48	28	17	40	15	42	38	80	2.95	−2.6	16	11.3	s.	49	sw.	2	5	4	22	7.7	.0	.0
Tacoma	263	172	201	29.93	30.14	+.13	42.3	+1.7	60	31	47	25	13	38	16	......	......	......	3.82	−2.9	19	9.0	s.	39	sw.	2	2	7	22	8.2	.0	.0
Tatoosh Island	86	9	55	29.98	30.08	+.12	45.0	+1.1	53	8	47	37	26	43	9	43	39	81	14.02	+.7	21	19.1	e.	67	sw.	2	6	5	20	7.4	.0	.0
Medford [1]	1,329	29	58	28.80	30.25	......	40.0	+2.6	61	31	46	24	13	34	28	38	36	86	2.18	−.9	10	......	n.	......	......	......	2	5	24	8.4	2.2	.0
Portland, Oreg	154	68	106	30.03	30.19	+.12	43.6	+2.4	61	7	48	29	15	39	15	41	37	77	4.16	−2.6	16	6.7	se.	26	s.	2	4	5	22	7.9	.6	.0
Roseburg	510	45	76	29.65	30.22	+.11	41.9	+.1	63	4	48	21	13	35	22	41	38	85	2.28	−3.1	9	3.3	n.	24	w.	1	1	6	24	8.5	.0	.0
Middle Pacific Coast Region							50.3	+2.4										74	3.04	−1.7										6.4		
Eureka	60	72	88	30.11	30.18	+.06	48.7	+.5	66	31	55	32	12	42	24	46	44	84	5.97	−.3	7	5.8	se.	30	sw.	2	8	4	19	6.5	.0	.0
Redding [1]	722	20	34	......	......	......	51.2	+5.1	77	7	60	32	30	43	33	44	34	56	4.02	−1.6	5	8.3	nw.	23	n.	11	6	9	16	6.5	.0	.0
Sacramento	66	92	115	30.07	30.14	.00	47.7	+1.5	64	15	55	31	26	41	23	45	42	81	.71	−2.3	7	5.4	n.	23	nw.	22	7	8	16	6.9	.0	.0
San Francisco	155	112	132	29.94	30.11	−.01	53.6	+2.3	67	7	59	43	31	48	18	49	45	76	1.48	−2.5	5	5.7	n.	20	w.	21	8	12	11	5.6	.0	.0
South Pacific Coast Region							57.1	+4.2										68	4.33	+2.3										5.6		
Fresno	327	9	105	29.77	30.13	.00	49.4	+3.2	69	17	57	33	25	42	27	47	43	80	1.47	.0	5	4.3	nw.	14	nw.	1	3	11	17	7.4	.0	.0
Los Angeles	338	159	191	29.68	30.05	−.02	62.3	+5.7	92	8	71	45	28	53	28	51	42	56	7.26	+4.6	8	6.6	ne.	24	nw.	1	14	11	6	4.1	.0	.0
San Diego	87	62	70	29.94	30.03	−.04	59.6	+3.6	84	8	68	44	28	51	28	52	47	68	4.25	+2.4	8	5.6	nw.	22	s.	14	11	6	14	5.3	.0	.0
West Indies																																
San Juan, P. R	82	9	54	29.87	29.96	......	76.8	+.5	90	17	81	70	23	73	16	......	......	......	5.46	.0	21	12.9	e.	32	e.	29	2	26	3	5.8	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Cristobal	36	6	97	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Alaska																																
Fairbanks	454	11	87	[2]29.15	[2]29.72	......	−3.1	+3.9	39	16	6	−38	29	−12	36	−3	−5	89	.52	−.1	8	3.9	n.	21	ne.	16	9	6	16	6.3	9.7	10
Juneau	80	96	116	[2]29.71	[2]29.80	......	32.3	+1.1	46	1	35	6	28	29	13	31	28	81	11.69	+4.0	25	9.4	s.	35	ne.	26	3	1	27	8.8	23.4	8.5
Nome	22	5	32	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	.5
Hawaiian Islands																																
Honolulu	38	86	100	29.98	30.02	......	74.0	+1.6	84	2	78	67	30	70	13	67	65	75	2.10	−1.9	13	10.2	e.	27	e.	15	8	16	7	5.2	.0	.0

LATE REPORTS FOR NOVEMBER 1938

District and station	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01 inch or more	Average hourly velocity	Prevailing direction	Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Panama Canal																																
Balboa Heights	118	6	92	......	[2]29.82	0.00	78.9	−0.2	89	18	85	71	11	73	17	......	......	[3]89	11.23	+0.7	23	4.3	nw.	20	nw.	19	2	21	7	6.9	0.0	0.0
Cristobal	36	6	97	......	[2]29.82	−.01	80.3	+1.0	89	14	86	73	29	75	15	75	74	[3]85	18.90	−3.3	26	5.9	w.	25	n.	25	0	11	19	7.7	.0	.0

[1] Observations taken at airport.
[2] Pressure not reduced to a mean of 24 hours.
[3] Observations taken bihourly.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, December 1938*

Stations	Altitude above mean sea level Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99												
Sydney, Cape Breton Island	48	29.77	29.91	+0.01	31.4	+2.4	36.7	26.2	56	11	5.19	−0.16	12.1
Halifax, Nova Scotia	88	29.69	29.96	+.01	31.8	+3.5	37.2	26.3	58	10	5.00	−.40	6.2
Yarmouth, Nova Scotia	65	29.87	29.98	+.02	33.0	+2.0	39.3	26.7	57	10	4.61	−.14	19.8
Charlottetown, Prince Edward Island	38	29.87	29.95	+.03	28.4	+3.2	33.7	23.0	54	3	4.84	+.23	24.2
Chatham, New Brunswick	28	29.82	29.93	−.02	22.1	+3.1	29.3	14.9	52	−13	3.20	+.01	11.2
Father Point, Quebec	20	29.96	29.97	+.01	22.1	+5.6	28.4	15.8	49	−6	3.05	+.34	16.1
Quebec, Quebec	296	29.67	30.01	.00	21.3	+5.7	27.0	15.6	42	−11	5.43	+2.04	32.0
Doucet, Quebec	1,236	28.49	29.90	−.12	10.4	+2.4	20.5	.2	45	−44	3.50	+.76	34.6
Montreal, Quebec	187	29.82	30.04	+.01	24.3	+4.7	29.9	18.8	44	−2	3.66	−.06	15.6
Ottawa, Ontario	236	29.76	30.02	−.03	20.4	+2.7	27.5	13.2	43	−13	2.25	−.59	11.5
Kingston, Ontario	285	29.71	30.03	−.02	28.5	+4.1	34.7	22.3	49	3	2.82	−.04	14.4
Toronto, Ontario	379	29.60	30.03	−.03	30.9	+3.4	36.0	25.8	51	9	2.23	−.35	14.1
Cochrane, Ontario	930	29.88	29.94	−.12	11.0	+3.0	18.5	3.4	34	−30	5.05	+3.48	46.5
White River, Ontario	1,244	28.57	29.98	−.03	12.4	+3.8	21.1	3.6	34	−46	3.19	+1.39	31.9
London, Ontario	808	29.13	30.03	+.03	27.0	+.2	33.0	20.9	46	−3	2.89	−.65	19.2
Southampton, Ontario	656	29.25	29.98	−.04	27.3	+.8	32.2	22.4	47	6	5.11	+1.23	45.0
Parry Sound, Ontario	688	29.28	29.99	−.03	24.8	+4.0	31.6	18.0	45	−11	6.01	+1.56	49.8
Port Arthur, Ontario	644	29.24	29.98	−.06	16.4	+2.8	24.4	8.5	36	−28	1.75	+.86	17.5
Winnipeg, Manitoba	760	29.10	30.01	−.09	10.4	+4.4	17.3	3.6	36	−35	1.18	+.27	11.8
Minnedosa, Manitoba	1,690	28.09	29.99	−.09	11.4	+3.4	19.1	3.7	39	−32	1.08	+.49	10.7
Le Pas, Manitoba	860	28.94	29.95	−.10	5.2	+5.0	13.4	−2.9	35	−35	.55	+.01	5.5
Qu'Appelle, Saskatchewan	2,115	27.61	30.00	−.08	13.3	+3.9	20.8	5.8	40	−34	1.45	+.72	13.9
Moose Jaw, Saskatchewan	1,759	27.92	29.98	−.14	18.0	+6.9	26.7	9.3	47	−30	1.11	+.52	11.1
Swift Current, Saskatchewan	2,392	27.10	30.04	−.04	19.1	+2.1	28.3	9.9	48	−30	.46	−.18	4.5
Medicine Hat, Alberta	2,365	27.44	30.04	−.02	21.6	+2.2	31.0	12.1	49	−41	1.04	+.36	10.3
Calgary, Alberta	3,540	26.24	30.04	−.01	22.2	+1.7	31.0	13.4	50	−28	.52	−.05	5.2
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.39	30.02	−.06	9.3	+4.1	17.9	.7	37	−42	.63	−.09	6.3
Battleford, Saskatchewan	1,592	28.18	30.01	−.06	8.8	+2.6	17.8	−.3	39	−46	1.00	+.59	10.0
Edmonton, Alberta	2,150	27.63	30.02	+.04	14.4	+.4	22.5	6.4	44	−46	1.81	+1.05	18.1
Kamloops, British Columbia	1,262	28.77	30.17	+.06	27.0	−.2	32.3	21.6	58	2	2.20	+1.23	18.7
Victoria, British Columbia	230	29.85	30.11	+.07	42.5	+1.5	46.4	38.6	55	31	6.34	+.96	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20												
Prince Rupert, British Columbia	170	29.70	29.89	+.06	38.5	+2.1	42.3	34.7	49	12	10.57	−1.15	2.6
St. George's, Bermuda	158		30.07	−.05	66.7	+1.9	71.3	62.2	79	51	6.78	+1.87	.0

LATE REPORTS FOR NOVEMBER 1938

Stations	Altitude above mean sea level Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
Cape Race, Newfoundland	99				38.8	+1.4	45.5	32.1	58	18	6.48	+.89	0.7
Montreal, Quebec	187	29.89	30.09	+0.07	37.9	+4.8	44.2	31.6	70	10	1.85	−1.62	4.1
Estevan Point, British Columbia	20	30.09	30.11	+.11	44.5	−.7	49.7	39.3	58	28	11.80	−.21	.0
Prince Rupert, British Columbia	170	29.78	29.96	+.13	41.2	−.2	45.8	36.5	57	28	10.59	−2.14	T

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TABLE 4.—*Severe local storms, December 1938*

[Compiled by Mary O. Souder from reports submitted by Weather Bureau Officials]

[The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Eureka, Calif., 15 miles south	1	12:21–12:43 p. m.				Thundersquall	Several old barns demolished by the wind.
Helena, Mont	3					Glaze	Streets and sidewalks dangerously slippery throughout the day.
Bordentown, N. J	6					Electric	An automatic feeder struck by lightning, killing 5 cows.
Ettrick, Va., vicinity of	9	6:30 p. m	300	0	$500	Tornado	Several buildings and trees blown down; path 3 miles long.
California, southern portion [1]	16			5		Rain	Blinding rain responsible for the lives of 5 men. 2 fishermen, 1 washed off the deck of a fishing boat, the other struck by a mast; 2 motorists hit by Pacific electric trains and another person struck by a car.
Wenatchee Valley, Wash	24	P. m				Wind	Property damaged, amount not estimated.
Takoma, Wash., and vicinity	24			1		Ice	Visibility less than 25 feet. Ice due to frozen fog. Several motor accidents reported; 3 persons injured.
Pennsylvania,[1] western portion	26	P. m				Sleet, snow, and wind.	Roofs blown off; trees uprooted; power and communication lines disrupted; highways blocked. In Latrobe, a roof of hospital blown off. In Uniontown, the Union Trust Co. building unroofed. On the William Penn Highway, about 40 miles east of Pittsburgh, 150 cars stalled. Traffic also blocked on the Lincoln Highway east of Greenburg. In many counties, snow fell at the rate of an inch an hour, the depths ranging from 3 to 7 inches.
Martin, S. Dak., vicinity of	26					Wind	Several buildings wrecked; haystacks blown over.
Fort Wayne, Ind	26–27					Snow and ice	1.6 inches of wet snow on the ground on the 26th froze on the 27th making walking and driving conditions hazardous.
West Virginia,[1] central portion	26–27					Wind	In Ellamore, during the night of the 26th, the power plant was damaged leaving the town in darkness. A brick wall fell in damaging a sawmill. Heavy damage to power lines in Belington. Wires down between Elkins and Parsons.
Michigan, Upper and Lower Peninsulas.	27					Wind and snow	Visibility reduced to zero with much drifting. Transportation at standstill; many automobiles blown off of slippery highways and ditched.
Buffalo, N. Y	27			2	50,000	do	Blizzard-like conditions persisted most of the day. Many persons injured. Maximum hourly wind velocities of 60 miles an hour lasted for more than 17 consecutive hours. Lake Erie rose 8 feet at Buffalo. Vessels and many small craft torn from their moorings along the lake front. Minor damage to cornices and roofs; number of plate glass windows broken and signs blown down. The Buffalo-Batavia Highway impassable during heavy, blinding snow.
Columbia, S. C	29–30					Glaze	Thin glaze remained on exposed objects from 6 a. m., of the 29th to 11:30 a. m., of the 30th.

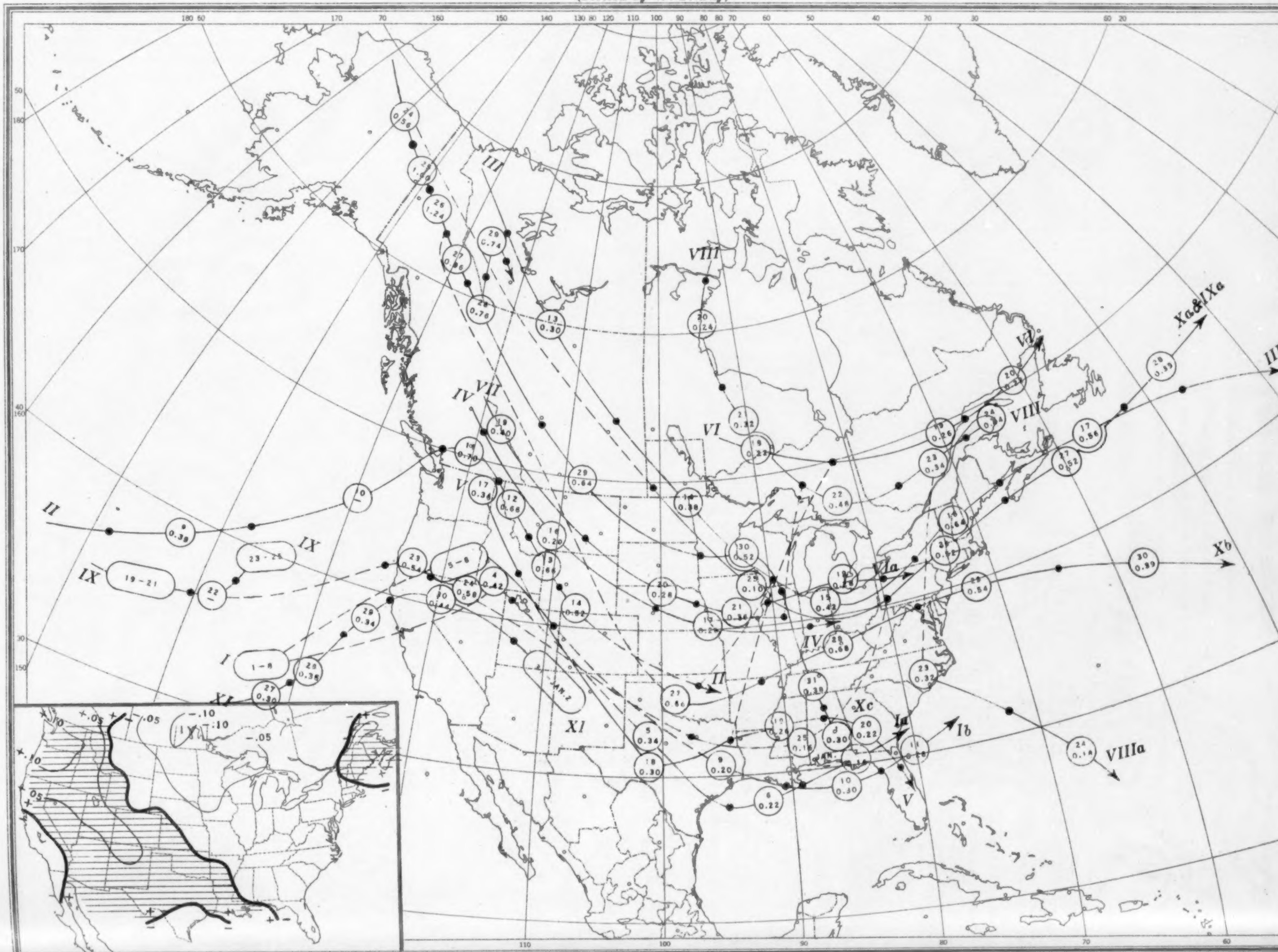
[1] From press reports.

U. S. GOVERNMENT PRINTING OFFICE: 1939

Chart I. Departure (°F.) of the Mean Temperature from the Normal, December 1938

Chart II. Tracks of Centers of Anticyclones, December 1938. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by W. P. Day)



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, December 1938. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. P. Day)

Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, December 1938

Chart V. Total Precipitation, Inches, December 1938. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, December 1938. (Inset) Departure of Precipitation from Normal

Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, December 1938

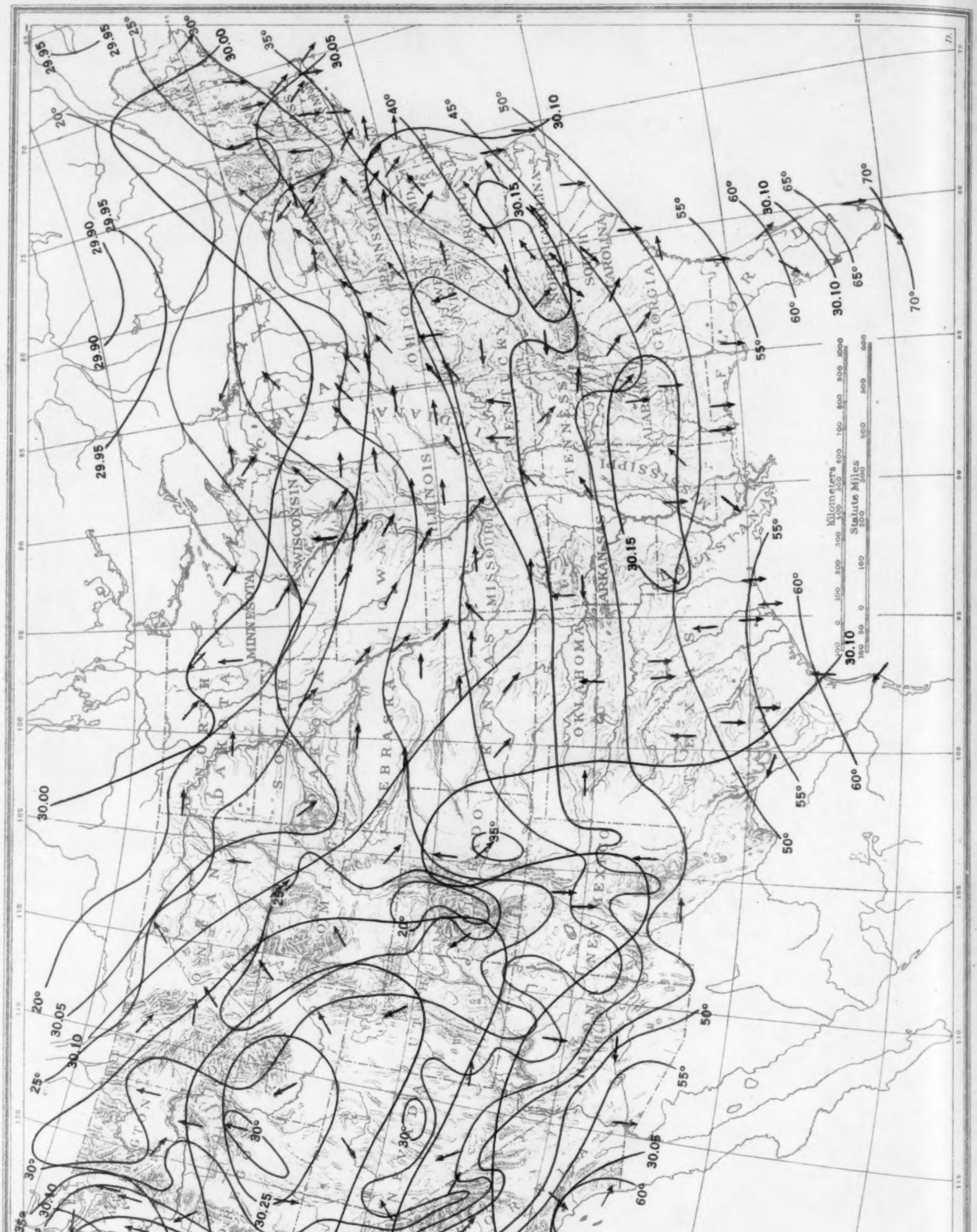


Chart VII. Wind Roses for Selected Stations, December 1938
(Plotted by J. P. Kohler)

Chart VII. Wind Roses for Selected Stations, December 1938
(Plotted by J. P. Kohler)

Chart VIII. Total Snowfall, Inches, December 1938. (Inset) Depth of Snow on the Ground at 7:30 p.m., Monday, Jan. 2, 1939

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UNITED STATES DEPARTMENT OF AGRICULTURE

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CORRECTION

October 1938, chart IX (at the back of the REVIEW): serial number should be "104".

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